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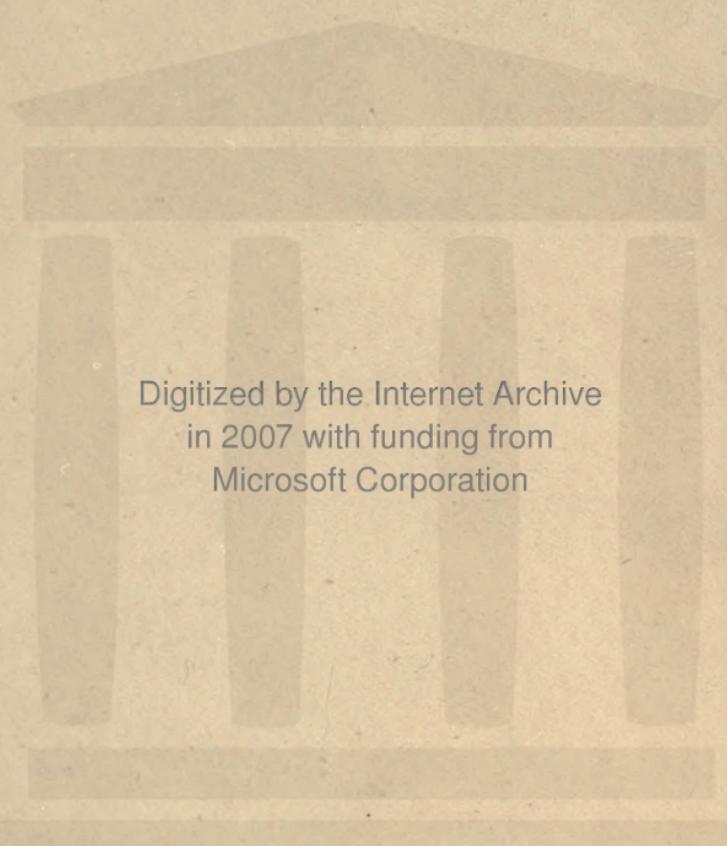


LITERARY MEDICAL MANUALS

GENERAL EDITOR:
SURGEON-GEN. SIR ALFRED KEOGH
G.C.B., M.D., F.R.C.P.

ABNORMAL FORMS OF TETANUS

COURTOIS-SUFFIT & GIROUX
EDITED BY
SURGEON-GEN. SIR DAVID BRUCE
& F. GOLLA



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MILITARY MEDICAL MANUALS

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**THE ABNORMAL FORMS OF
TETANUS**

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THE ABNORMAL FORMS OF TETANUS

A CLINICAL, PATHOGENIC, PROPHYLACTIC, AND
THERAPEUTIC SURVEY

BY

M. COURTOIS-SUFFIT & R. GIROUX

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WITH A PREFACE BY
PROFESSOR FERNAND WIDAL

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GENERAL INTRODUCTION

THE infinite variety of injuries which any war presents to the surgeon gives to military surgery a special interest and importance. The special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, for if we read the older writers we find little in the moderns that is new in this respect but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist, and indeed of every form of scientific assistance, in the solution of their respective problems. The clinician entered upon the great war armed with all the resources which the advances of fifty years had made available. If the surgical problems of modern war can be said not to differ sensibly from the campaigns of the past, the form in which they have been presented is certainly as different as are the methods of their solution. The achievements in the field of discovery of the chemist, the physicist and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements, it would be wrong to assume that modern scientific knowledge was, on the outbreak

of the war, immediately useful to those to whom the wounded were to be confided. Fixed principles existed in all the sciences auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign ; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements—indeed, the requirements were not fully foreseen ; the workers in the various fields were isolated, or isolated themselves, pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be—and that they have been of surpassing splendour no one will be found to deny—experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the “Horizon” Collection, which has been appropriately named after the uniform of the French soldier.

The authors, who are all well-known specialists in the subjects which they represent, have given a concise but eminently readable account of the recent acquisitions to the medicine and surgery of war which had hitherto been disseminated in periodical literature.

No higher praise can be given to the Editors than to say that the clearness of exposition characteristic of the French original has not been lost in the rendering into English.

MEDICAL SERIES

The medical volumes which have been translated for this series may be divided into two main groups, the first dealing with certain epidemic diseases, including syphilis, which are most liable to attack soldiers, and the second with various aspects of the

neurology of war. The last word on *Typhoid Fever*, hitherto "the greatest scourge of armies in time of war," as it has been truly called, will be found in the monograph by MM. Vincent and Muratet, which contains a full account of recent progress in bacteriology and epidemiology as well as the clinical features of typhoid and paratyphoid fevers. The writers combat a belief in the comparatively harmless nature of paratyphoid and state that in the present war haemorrhage and perforation have been as frequent in paratyphoid, as in typhoid fever. In their chapter on diagnosis they show that the serum test is of no value in the case of those who have undergone anti-typhoid or anti-paratyphoid vaccination, and that precise information can be gained by blood cultures only. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum-therapy and vaccine-therapy and the general management of the patient.

Considerable space is devoted to the important question of the carrier of infection. A special chapter is devoted to the prophylaxis of typhoid fever in the army. The work concludes with a chapter on preventive inoculation, in which its value is conclusively proved by the statistics of all countries in which it has been employed.

MM. Vincent and Muratet have also contributed to the series a work on *Dysentery, Cholera and Typhus* which will be of special interest to those whose duties take them to the Eastern Mediterranean or Mesopotamia. The carrier problem in relation to dysentery and cholera is fully discussed, and special stress is laid on the epidemiological importance of mild or abortive cases of these two diseases.

In their monograph on *The Abnormal Forms of Tetanus*, MM. Courtois-Suffit and Giroux treat of those varieties of the disease in which the spasm is confined to a limited group of muscles, e.g. those of the head, or one or more limbs, or of the abdomino-

thoracic muscles. The constitutional symptoms are less severe than in the generalized form of the disease, and the prognosis is more favourable.

The volume by Dr G. Thibierge on *Syphilis in the Army* is intended as a *vade mecum* for medical officers in the army.

Turning now to the works of neurological interest, we have two volumes dealing with lesions of the peripheral nerves by Mme. Atanassio Benisty, who has been for several years assistant to Professor Pierre Marie at La Salpêtrière. The first volume contains an account of the anatomy and physiology of the peripheral nerves, together with the symptomatology of their lesions. The second volume is devoted to the prognosis and treatment of nerve lesions.

The monograph of MM. Babinski and Froment on *Hysteria or Pithiatism and Nervous Disorders of a Reflex Character* next claims attention. In the first part the old conception of hysteria, especially as it was built up by Charcot, is set forth, and is followed by a description of the modern conception of hysteria due to Babinski, who has suggested the substitution of the term "Pithiatism," *i.e.* a state curable by persuasion, for the old name hysteria. The second part deals with nervous disorders of a reflex character, consisting of contractures or paralysis following traumatism, which are frequently found in the neurology of war, and a variety of minor symptoms, such as muscular atrophy, exaggeration of the tendon reflexes, vasomotor, thermal and secretory changes, etc. An important section discusses the future of such men, especially as regards their disposal by medical boards.

An instructive companion volume to the above is to be found in the monograph of MM. Roussy and Lhermitte, which embodies a description of the psychoneuroses met with in war, starting with elementary motor disorders and concluding with the most complex represented by pure psychoses.

SURGICAL SERIES

When the present war began, surgeons, under the influence of the immortal work of Lister, had for more than a quarter of a century concerned themselves almost exclusively with elaborations of technique designed to shorten the time occupied in or to improve the results obtained by the many complex operations that the genius of Lister had rendered possible. The good behaviour of the wound was taken for granted whenever it was made, as it nearly always was, through unbroken skin, and hence the study of the treatment of wounds had become largely restricted to the study of the aseptic variety. Septic wounds were rarely seen, and antiseptic surgery had been almost forgotten. Very few of those who were called upon to treat the wounded in the early autumn of 1914 were familiar with the treatment of grossly septic compound fractures and wounded joints, and none had any wide experience. To these men the conditions of the wounds came as a sinister and disheartening revelation. They were suddenly confronted with a state of affairs, as far as the physical conditions in the wounds were concerned, for which it was necessary to go back a hundred years or more to find a parallel.

Hence the early period of the war was one of earnest search after the correct principles that should be applied to the removal of the unusual difficulties with which surgeons and physicians were faced. It was necessary to discover where and why the treatment that sufficed for affections among the civil population failed when it was applied to military casualties, and then to originate adequate measures for the relief of the latter. For many reasons this was a slow and laborious process, in spite of the multitude of workers and the wealth of scientific resources at their disposal. The ruthlessness of war must necessarily hamper the work of the medical scientist in almost every direction except in that of

providing him with an abundance of material upon which to work. It limits the opportunity for deliberate critical observation and comparison that is so essential to the formation of an accurate estimation of values ; it often compels work to be done under such high pressure and such unfavourable conditions that it becomes of little value for educational purposes. In all the armies, and on all the fronts, the pressure caused by the unprecedented number of casualties has necessitated rapid evacuation from the front along lines of communication, often of enormous length, and this means the transfer of cases through many hands, with its consequent division of responsibility, loss of continuity of treatment, and absence of prolonged observation by any one individual.

In addition to all this, it must be remembered that in this war the early conditions at the front were so uncertain that it was impossible to establish there the completely equipped scientific institutions for the treatment of the wounded that are now available under more assured circumstances, and that progress was thereby much hampered until definitive treatment could be undertaken at the early stage that is now possible.

But order has been steadily evolved out of chaos, and many things are now being done at the front that would have been deemed impossible not many months ago. As general principles of treatment are established it is found practicable to give effect to them to their full logical extent, and though there are still many obscure points to be elucidated and many methods in use that still call for improvements, it is now safe to say that the position of the art of military medicine and surgery stands upon a sound foundation, and that its future may be regarded with confidence and sanguine expectation.

The views of great authorities who derive their knowledge from extensive first-hand practical experience gained in the field cannot fail to serve as a

most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great ally, France, to the common cause is this brilliant contribution to our professional knowledge.

A glance at the list of surgical works in the series will show how completely the ground has been covered. Appropriately enough, the series opens with the volume on *The Treatment of Infected Wounds*, by A. Carrel and G. Dehelly. This is a direct product of the war which, in the opinion of many, bids fair to become epoch-making in the treatment of septic wounds. It is peculiar to the war and derived directly from it, and the work upon which it is based is as fine an example of correlated work on the part of the chemist, the bacteriologist and the clinician as could well be wished for. This volume will show many for the first time what a precise and scientific method the "Carrel treatment" really is.

The two volumes by Professor Leriche on *Fractures* contain the practical application of the views of the great Lyons school of surgeons with regard to the treatment of injuries of bones and joints. Supported as they are by an appeal to an abundant clinical experience, they cannot fail to interest English surgeons, and to prove of the greatest value. It is only necessary to say the *Wounds of the Abdomen* are dealt with by Dr Abadie, *Wounds of the Vessels* by Professor Sencert, *Wounds of the Skull*

and Brain by MM. Chatelin and De Martel, and *Localisation and Extraction of Projectiles* by Professor Ombrédanne and R. Ledoux-Lebard, to prove that the subjects have been allotted to very able and experienced exponents.

ALFRED KEOGH

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PREFACE

OF all the infections which menace our wounded soldiers, tetanus is that which we may most readily prevent. All the statistics published during the last year are unanimous in demonstrating how rare this malady is in subjects who, after a wound, are immediately treated by antitetanic serum. Serotherapy, on the other hand, when delayed and insufficient, may help to create a special type of attenuated and localised tetanus : a fact fully established by the experience of the present war. In this form of the disease the contracture, as a rule, is confined to a single limb—that which has been wounded—and is accompanied by spasmodic attacks of varying frequency, without tending to become permanently general. This type is not always strictly monoplegic ; the contractions may sometimes invade the opposite limb, but the development is always so benign that recovery is the rule. If examples of such cases are not very numerous, this is doubtless because physicians are not as yet very well acquainted with their existence.

As we owe to MM. Courtois-Suffit and Giroux one of the first and most important observations of this new type, no one is better qualified to describe its characteristic features. This they have done in a remarkable manner, basing their remarks upon all the documentary evidence hitherto published, after having first set forth the individual characteristics of those other atypical

and partial forms of tetanus which have long been known, such as cephalic tetanus and splanchnic tetanus.

The local tetanus of the limbs does not merely present the interest of a clinical novelty ; its special pathogenesis gives to its history a general significance, upon which the authors of this volume have not failed to insist.

Just as we sometimes observe the development of an attenuated form of typhoid fever in subjects who have been insufficiently vaccinated, so tetanus may remain localised in the injured member when serotherapy has been applied under certain conditions which render it only partially effective. We have then to deal with a tetanus which, owing to immunisation, is incomplete ; a tetanus which is an excellent example of those modified morbid types with which preventive medicine is gradually enriching the natural history of the infectious diseases.

The powerful preventive action of antitetanic serum should not result in a failure to appreciate its curative action, the utility of which is incontestable in the treatment of certain cases of confirmed tetanus. If the antitoxin can no longer avail against the toxin already fixed by the nervous elements, it may still be wholly effectual against the toxin which those tetanic bacilli which have not been destroyed may continue to discharge in the region of the wound. When, therefore, the first symptoms of tetanus appear in a wounded man, antitetanic serum should always be injected in large quantities, whether it has or has not been previously employed for prophylaxis.

A specific remedy, however powerful, cannot combat

all the complex elements which go to make up a disease. Tetanus, in the beginning, arises as a simple infectious focus in the region of a wound area ; but, owing to the selective action of the toxin which is secreted by the tetanus microbe, it becomes manifest as a disease of the nervous system. In order, therefore, to cope with it, a symptomatic medication should come to the aid of the pathological medication. If he can contrive to alleviate the fits of painful muscular contraction, the physician will sometimes enable the patient to pass the dangerous stage of the affection, and will thus be able to safeguard him as far as the period of cellular repair—that is, to recovery.

MM. Courtois-Suffit and Giroux, with a full knowledge of the subject, have very lucidly expounded all these precepts, which are so fully applicable to the partial forms of tetanus. They have also reflected that at the present moment it is impossible to touch upon any point of the history of tetanus without recalling the magnificent development of bacteriology, which, proceeding from the discovery of the tetanus bacillus to that of its toxin, and then to that of the antitoxin, has provided us with the means of preserving our soldiers from this disease. For this reason this volume, despite the limitations expressed by its title, offers an extremely valuable summary of the knowledge which every physician ought to possess concerning the etiology, pathogenesis, prophylaxis, and treatment of the most formidable of the complications which may arise from wounds received in battle.

PROFESSOR VIDAL,
Of the French Academy of Medicine.

PREFACE TO ENGLISH EDITION

THE work of MM. Courtois-Suffit and Giroux should prove to be of considerable interest to the clinician. It constitutes the first attempt to collect and classify in a single monograph the various forms of abnormal tetanus that are daily occurring among our wounded, and which owe their divergence from the classical type in a great degree to prophylactic treatment. Our knowledge of tetanus as modified by prophylaxis has hitherto been very incomplete, and the British Army Medical Department is to be congratulated on its action in establishing a special committee for the general investigation of the disease and collection of statistics relating to it. The incidence of tetanus is small, about three per thousand wounded, though in view of the large number of wounded and the terrible nature of the disease it is deserving of the most serious study. It is this small percentage incidence that makes investigation so difficult without some central body such as the War Office Committee for the Study of Tetanus. Few clinical units see a sufficient number of cases to arouse much interest among the individual members of the medical staff, although the total number of cases reported runs into four figures. Another disadvantage of the scattered incidence of tetanus is that entirely illusory results are claimed for treatment based on

small collections of cases studied at some particular hospital.

The extent to which prophylaxis has altered the nature of tetanus is shown by the frequent occurrence of local tetanus of the limbs. This type, which was extremely rare in pre-serum days, and is still characterised as rare by MM. Courtois-Suffit and Giroux at the time of writing their monograph, occurred in 119 cases among 526 cases of reported tetanus during certain months of 1916. The English type of local tetanus of the limbs is only recognised in those cases in which there is never trismus or other cranial nerve involvement, and hence a purer type is constituted than that recognised by the authors of this monograph, who extend the diagnosis to cover cases with slight trismus and affection of the neck muscles. Inasmuch as the true local tetanus has practically no mortality it may readily be seen how the inclusion of such cases in statistics of tetanus has reduced the apparent mortality of the disease, and incidentally encouraged many observers to regard the reduction of mortality as a demonstration of the efficacy of some particular form of treatment. There is no uniformity in treatment. One vaunts the superiority of magnesium sulphate, another of carbolic acid. One thinks the subcutaneous injection of antitoxin gives the best results, others swear by the intravenous or intratheral route. Nothing is really known as to the effect of the various methods of treatment. One would be inclined to say, from a study of the results, that they are all equally useless. One fact alone tends to emerge, and that is the undoubted effect which antitoxin given prophylactically has in modifying the disease.

In no disease is there more urgent necessity for collective investigation than in tetanus.

DAVID BRUCE.
FREDERICK GOLLA.

INTRODUCTION

IN addition to generalised tetanus, the ordinary, most commonly observed form, in which the contractions affect all the muscles of the voluntary system, there are partial, localised, atypical forms.

These are characterised, in the first place, by the absence of any generalised infection, so that the term "localised tetanus" must be reserved only for those cases in which the presence of contracture in a certain segmental area does not merely constitute the first phase of the disease. We shall see that a very fugitive and attenuated extension of the clinical phenomena, either to the face, the nape of the neck, or the trunk may take place, but this extension, in partial tetanus properly so called, is always transient, being confined to a mere stiffness never dominating the clinical picture, and does not deprive the atypical development of the malady of any of its characteristic traits. The fact that the initial and permanent seat of the infection is in one of the limbs, for example, makes this form of tetanus a *local malady*.

Thus understood, the partial atypical forms are far from frequent. Some of these are well known, and have been made the subject of clinical descriptions which render it possible to individualise them; others, only recently observed, at all events as far as the localisation of the tetanic infection in a single member is concerned, have so far no definite clinical history.

INTRODUCTION

The partial forms of tetanus of the limbs are those on which we propose more especially to insist, while analysing a certain number of interesting observations which we have selected.

We shall therefore divide this survey of the atypical forms of tetanus into two parts. In the first we shall rapidly describe the already known atypical forms of the disease—that is to say, sphincteric tetanus, and the different varieties of non-sphincteric partial tetanus. This group contains, according to the seat of localisation, in the first place, cephalic tetanus, which comprises four forms :

1. Cephalic tetanus without paralysis.
2. Cephalic tetanus with facial paralysis.
3. Cephalic tetanus with paralysis of the motor nerves of the eye.
4. Cephalic tetanus with paralysis of the hypoglossal, giving the syndrome of labio-glosso-pharyngeal paralysis, of which a few cases have been reported.

A unilateral form of tetanus may also be observed in which the contractions are localised, principally if not exclusively, on one side of the body. This, however, is not, properly speaking, an atypical partial form.

In the *second portion* of this volume we have endeavoured to describe, in detail, the clinical history of the atypical tetanus of the limbs. The partial atypical affection of the limbs may assume two clinical types :

1. The monoplegic variety, which is that on which we especially desire to dwell.
2. The paraplegic variety.

In connection with these interesting atypical forms, which are at present the subject of numerous

communications, we have noted the form described by Claude and Lhermitte, under the name of "Attenuated Tetanus with Slow Development and Prolonged Incubation."

Having considered the etiology and the pathogenesis of these atypical forms, we have finally dealt at length with the prophylactic treatment and the various therapeutic methods employed in the treatment of tetanus, and in particular of atypical tetanus. The serotherapeutic and symptomatic treatments must be combined if we wish to give the patient every chance of recovery, or at least the best chance.

THE ABNORMAL FORMS OF TETANUS

PART I.—THE KNOWN ATYPICAL FORMS OF TETANUS

THE various manifestations of the tetanic infection permit of the differentiation of a great variety of clinical forms.

According to the development of the disease, the predominance of certain indications, the etiology of the case, and its severity, we may describe a whole series of individual forms.

Many of these fall under the heading of the classic tetanus, and do not constitute atypical forms. Thus, for example, the super-acute forms of tetanus are merely a particular modality of the disease dependent upon the gravity of the symptoms immediately after their appearance. It follows, therefore, that sphincteric tetanus is not, properly speaking, an atypical form. We shall mention it only, without enlarging upon it, for if the contractions are not generalised the cause is to be found principally in the very rapid development of the disease and its fatal termination within twenty-four to forty-eight hours.

On the other hand, cephalic tetanus is a truly atypical and partial form of the infection ; we shall accordingly examine its four varieties, which are :

1. Cephalic tetanus without paralysis.

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2. Cephalic tetanus with facial paralysis.
3. Cephalic tetanus with paralysis of the motor nerves of the eye.
4. Cephalic tetanus with paralysis of the hypoglossal.

Having examined each of these forms, we shall terminate this chapter by a rapid summary. We propose in this to show that the varieties of cephalic tetanus are merely modifications of the clinical type first described and definitely isolated by Rose, who contributed a masterly study of the type to Pitha and Billroth's manual.

SPHLANCNIC TETANUS

Sphænætic tetanus may be regarded as a partial form of tetanus in this sense, that death usually occurs before the contractions are generalised.

It is characterised essentially by the involvement of the muscles of deglutition and respiration, which explains the intensity of the dysphagia observed (a symptom which at the outset might lead us to suppose that we had to deal with a severe angina), by the intensity of the hydrophobia, and the crises of suffocation due to spasms of the glottis and of other muscles of the respiratory system. The dyspnoea is very marked, and the asphyxial phenomena rapidly become menacing.

From these indications it will be understood that the forms of non-paralytic cephalic tetanus which may or may not be accompanied by accentuated dysphagia or hydrophobia are to be regarded as coming under the heading of sphænætic tetanus.

The contractions of the muscles of deglutition and respiration are accompanied and sometimes preceded

by a short interval of trismus and stiffness of the neck. This is, in short, a form of partial atypical tetanus, localised in the muscles of deglutition and respiration, and the muscles of the head and neck.

The prognosis is grave, and almost always fatal.

The development is very rapid, and death occurs within twenty-four to forty-eight hours.

This form of tetanus usually follows a visceral infection.

Its period of incubation is usually long: eight or ten days, or sometimes more.

CEPHALIC TETANUS

Cephalic Tetanus without Paralysis

Certain writers have seen fit, wrongly, as we think, to multiply the forms of cephalic tetanus, basing their classification either on the development of the disease, or on its degree of severity, or on the group of muscles affected by the contractions. Thus acute, chronic, continuous, remittent, pyretic, apyretic, analgesic, hyperalgesic, ocular, cervical, masseteric, generalised, localised, dysphagic, hydrophobic, oesophageal, and other forms have been described. It must, however, be recognised, if the numerous observations of cephalic tetanus be analysed, that clinical varieties exist which are plainly defined not only by the objective indications, but also by the progress of the disease, and by the prognosis. It is therefore impossible, save at the cost of lucidity, to include in the same description the true hydrophobic tetanus with its alarming paroxysms of dysphagia and respiratory troubles, provoked by the mere sight of a glass of water, and without any paralytic phenomena, and the varieties of tetanus with facial

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paralysis or paralysis of the motor nerves of the eye.

We shall therefore describe, under the head of the non-paralytic forms of cephalic tetanus, in addition to the simple cephalic variety, characterised only by trismus and contractions of the muscles of the face and neck, the dysphagic types, which may vary from a simple difficulty of deglutition to hydrophobia.

1. Simple Cephalic Tetanus.—In this rare form of the disease the infection is confined to the cephalic region, as a result, most frequently, of a wound in the head. It is accompanied only by unilateral or bilateral trismus, or by contractions of certain muscles of the facial or even of the cervical region. But in this type there are *never dysphagic or paralytic symptoms*.

2. Cephalic Tetanus of the Dysphagic Type.—Eliminating those cases in which there is simultaneously dysphagia and facial paralysis, we may clinically define two types, which are sometimes, however, combined. These are :

The purely dysphagic form.

The hydrophobic form.

(a) *Dysphagic Form.*—Although this variety differs definitely from the hydrophobic form in highly accentuated cases, this is no longer the fact in cases of generalised tetanus. In such cases the respiratory symptoms make their appearance, and hydrophobia becomes the second stage of the infection. Insensibly the disease passes from the dysphagic to the hydrophobic variety.

However this may be, this form is characterised by a pharyngeal spasm which precedes the trismus, or is associated with it. The trismus, at the outset, is unilateral. The patient is sensible of pain and tension on

one side of the jaw, the side corresponding to the wound. This tension presently becomes a continuous contraction, with convulsive paroxysms. The trismus remains thus unilateral for a variable period, usually four to five days ; but as a rule, when the patient seeks advice, the indications have become threatening and the trismus is complete.

The trismus is almost invariably accompanied by cervical opisthotonus. This may be present in any degree, from a mere stiffness of the neck to the retroversion of the head. It makes its appearance shortly after the trismus. Paroxysms of the affected muscles may be aroused by the slightest excitation, such as touching the wound (Charvot), but their most frequent cause is the voluntary or spontaneous separation of the jaws.

The pharyngeal spasm causes more or less accentuated dysphagic disorders, which attain their maximum of intensity in the hydrophobic form. The patient can swallow no food ; and the least absorption of liquid sets up painful spasms of the pharynx.

Generally speaking, however, the disorders of deglutition are, more often than not, of no great severity.

Apyrexia is the rule, at all events at the outset. The temperature will rarely exceed 100·4° F.

Lastly, in addition to the cardinal symptoms, dysphagia and contraction of the muscles of the neck, we sometimes observe an intense dyspnœa, which contributes to the seriousness of the prognosis of this variety of atypical tetanus.

(b) *Hydrophobic Form.*—This is a very rare and exceptional form, and Réclus, on studying all the observations of cephalic tetanus, discovered only two in which a true hydrophobia was present.

In addition to the phenomena of dysphagia, and the

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muscular contractions, there are alarming convulsions, provoked, in the majority of cases, either by touching the pharynx, by a movement of deglutition, or even by the mere sight of a liquid, or the utterance in the patient's presence of a phrase or word having reference to drinking.

These paroxysms manifest themselves by violent convulsive spasms, the initial seat of which is often the wound, with irradiation into the muscles of the face (masseteric or other), the neck, and the pharynx, occasionally attaining even the diaphragm; when contractions of the respiratory muscles occur, with dyspnoea and asphyxial phenomena.

Moreover, generalisation of the tetanus is frequent in this form, and the prognosis is almost invariably fatal. Even in the absence of generalisation the asphyxial phenomena and inanition may determine the fatal issue of the case.

Cephalic Tetanus with Facial Paralysis

This form of tetanus, described by Poan de Sapincourt as the facial form of the disease, had already been remarked by Rose. It is the most frequent form, and we therefore propose to study it at greater length than the others, basing our remarks on the highly interesting and fully documented thesis of Poan de Sapincourt. This variety arises from one cause only: a wound in the face or the neighbourhood of the face. It is characterised by:

1. Contractions which usually commence in the masticatory muscles of the wounded side (unilateral trismus), often invading the other side, and the musculature of the neck. They may become generalised.

2. Disorders of deglutition, of much less importance than in the preceding forms.

3. A facial paralysis, almost always localised on the side of the wound (facial hemiplegia), or, when the wound is situated on the median line, a paralysis of both sides (facial diplegia).

History

This form of tetanus has been known for some forty years, and was for the first time described by Rose, in 1872. In the two observations recorded by this writer the tetanic contractions resulted from a wound of the face; and in both patients Rose was struck by the appearance of a muscular paralysis of that side of the face on which the wound was situated.

He described the clinical aspect of the malady, and carefully studied the three cardinal symptoms:

1. Wound in the region of the cranial nerves.

2. Appearance of facial paralysis, most frequently on the injured side.

3. Tetanic contractions extending from the masseter to all the facial muscles, the muscles of the neck, and the muscles of the pharynx and the œsophagus.

Numerous observations have been recorded since the date of this first essay, and in 1888 Villar summed up the whole question in the course of a general survey.

Two years later, in 1890, appeared the thesis of Dr Albert (of Lyons); following which fresh observations were published, and Janin, in his thesis (1892), referring to two personal observations, returned to the subject, dividing tetanus, according to the predominant localisation of the tetanic toxin in the nervous centres, into medullary tetanus (generalised tetanus) and bulbar

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tetanus (cephalic tetanus with paralysis of the facial muscles).

In the same year Landouzy cited a case in which there was only an appearance of facial paralysis. Réclus reported some personal observations in 1893, and in the following year Houques published his third thesis, entitled *Cephalo-paralytic Tetanus*, in which the writer made mention of no fresh facts, but, from the pathogenic point of view, put forward a theory of indirect origin. He admitted an original lesion by contusion of the terminal branches of the trigeminus against a resisting plane (osseous or external), the tetanic infection being said to invade the facial nerve, after first invading the bulb, in which the facial and masseteric nuclei are adjacent. Observation followed observation, and in 1896 appeared the last thesis of Le Dard, which dealt particularly with facial paralysis in tetanus.

Finally, we may mention the observations of Crouzon, Bourgeois, and Lortat-Jacob, the latter inspiring the work of Poan de Sapincourt (1904); and then the case observed by Binet and Trenel, in connection with which these writers briefly summarised the question of the cephalic forms of tetanus.

Etiology, Frequency, Age, and Sex

Cephalic tetanus is a rare affection, whose general etiology is that of the classical tetanus.

It must be remembered that this facial form of tetanus never occurs except as the result of a wound of the face, whether external or internal, in the region innervated by the facial nerve. This feature, according to Poan de Sapincourt, is pathognomonic.

In considering the special etiology of this form of the

disease we must again note the connection between the facial paralysis and the position of the wound, since in the majority of cases the facial hemiplegia is found on the side of the wound by which the infection has entered. And, when the wound is median, there is facial diplegia.

As in the classical tetanus, men appear to be more exposed to the disease than women. Age appears to exert a certain influence, for this atypical form of the disease has been observed more particularly in youth and maturity, although it has been encountered at all ages.

We shall not further insist on the rôle of the seasons, or of professional factors, in the etiology of this form, for all that might be said would apply with equal force to the classic forms of tetanus.

Clinical Survey

Insidious in its onset, rather tardy in establishing itself, treacherous in its progress, and, owing to its complications, involving a slow recovery or a somewhat speedy death—such, in a few words, are the general characteristics of the facial form of the tetanic infection (Poan de Sapincourt).

Following a wound in the face, insignificant in the majority of cases, and caused by a fall on a stony road, or the bite of a horse, or a bullet wound, or even by a neglected ulceration, and after a period varying from two to twenty-two days (on an average, eight days) during which there are no premonitory symptoms (neither fever, nor fatigue, nor shivering, nor pains, nor insomnia) announcing the onset of the malady, the patient awakes one morning with a stiffness in one or both jaws. Sometimes there is pain at the same time.

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Difficulty of mastication and of speech follow.

Presently this stiffness and constraint give way to muscular contraction and spasms, and the characteristic trismus makes its appearance. At this period the wound in which the toxins are produced is usually cicatrised, and the patient, no longer regarding it as of any importance, calls the attention of the physician only to the pain and the trismus.

These symptoms then increase in intensity, and the patient is obliged to take to his bed. The opposite side of the face may become contracted, and the wounded side is completely paralysed. We have to deal with a typical facial paralysis, the mouth crooked and drooping, allowing the saliva to trickle out ; the labial furrow is effaced, the cheeks are flaccid, wrinkles have disappeared, and the eye is widely opened.

Contracture and paralysis, moreover, are frequently associated, and the patient's face assumes the hideous mask described as the *risus sardonicus*.

The paralysis alarms the patient, while his attention is centred upon the persistence and increase of the pains, which become unendurable, the closing of the jaws, which become more and more firmly shut, the insomnia, and the prospect of no longer being able to take food. Indeed, the absorption of liquids is already difficult, and gives rise not only to pain but to paroxysmal contractions. For this reason the patient, when the paroxysm is over, fearing its return, finally refuses all nourishment.

The clinical picture is sometimes completed by dysphagia ; at each attempt at deglutition the contractions occur, and may even lead to an actual hydrophobia.

These local symptoms having fully developed, the

malady progresses slowly in the direction of recovery, or else the contractions may become more or less rapidly generalised, the local atypical malady henceforth assuming the aspect of the classic, generalised form of tetanus, with its serious prognosis.

Such, in its most frequent form, and briefly described, is the clinical aspect of cephalic tetanus with facial paralysis. We propose now to insist yet further upon the individual signs of this type, in order that we may clearly demonstrate its characteristics.

Individual Signs of Cephalic Tetanus with Facial Paralysis

1. Situation of the Wound.—We think it as well again to call attention to the fact that this facial form of cephalic tetanus has *never* been observed save as following upon a wound of the head, though, as Poan de Sapincourt has justly remarked, this does not mean that every wound in the head infected by Nicolaïer's bacillus will result in facial paralysis.

Moreover, in all the observations published one is struck by the far from extensive and occasionally superficial localisation of the wounds in which the tetanic infection has originated.

They are situated more particularly on the upper or lower border of the orbit, the superciliary ridge, the root of the nose, the malar region, or the inferior portion of the frontal region. In one single case the wound was occipital. In short, the traumatic lesions are situated in the area innervated by the two branches of the facial nerve, and above all by the superior division of the facial nerve, and Villar has given to this area the name of the orbito-naso-temporo-malar

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region, thus summarising the common localisations of the wounds which give rise to cephalic tetanus.

2. Incubation. — The period of incubation is not accompanied by any indication which leads us to suspect probability of local tetanus. The wound, as a rule, becomes cicatrised in a normal manner, unless, as is often the case, it contains some foreign body. This phase lasts, on an average, nine days, but it may be shorter.

The first symptoms have been known to appear at the end of two days. Sometimes the period of incubation is longer ; it may be as long as twenty-two days.

During the period of incubation slight pain in the neighbourhood of the wound and in the temporo-maxillary articulation may be sometimes noted. Once the period of incubation is over the characteristic signs make their appearance with some degree of suddenness.

3. Trismus. — This symptom is almost always the first to appear. Sometimes isolated, sometimes associated with facial paralysis, it is occasionally accompanied by dysphagia or dyspnœa.

The trismus is confined, at the outset, to a transient discomfort in the jaw. Pain is felt upon pressure in the masseteric region, or when the patient attempts to open his mouth. The trismus is at this stage unilateral, and is situated on the same side as the wound, but it very soon becomes bilateral, although it remains predominant on the wounded side.

There is nothing surprising in this initial localisation, for we have learned experimentally that the contracture always makes its first appearance in the muscles neighbouring upon the place of inoculation.

4. Muscular Contractions.—These rarely appear before the trismus, or simultaneously with it. They are usually observed afterwards, and may invade all the muscles of the face, and neck.

They may be situated on the same side as the facial paralysis, or on the opposite side, or even on both sides (in the case of a median wound), but in general they commence on the paralysed side.

The contractions are variable in degree ; they may amount to a mere stiffness, or in very marked cases they may cause the immobilisation of the head in an unnatural attitude, giving rise to cervical opisthonotos.

As in the classical form of tetanus, these contractions are tonic, but spasmodic paroxysms may be aroused by the slightest excitation (touching the wound, or movements of mastication or deglutition).

We can understand the difficulties of the clinicians when confronted by a lesion of the facial nerve producing paralysis and contraction in *the same muscles*.

Nevertheless, it is possible to explain this phenomenon : for the paralysis and the contractions do not act in the same direction, nor in the same nervous territories. As Pechoutre contends, contraction is a phenomenon which has a central point of departure, while paralysis, at least in the beginning, results from a change in the peripheral nerve branches neighbouring upon the wound, due to the tetanic toxin (Roux, Borel, Marie, Morax).

These two symptoms have thus been explained by Guiffré, and his explanation is very probable : "The contractions of the facial muscles affected by paralysis," he says, "do not in this case differ in any way from the ordinary tetanic contractions, except that they occur in muscles already paralysed. To explain this fact we

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may suppose that the voluntary impulse is not sufficiently transmitted by the affected nerves to the muscles of the periphery, while the tetanic toxin, on the contrary, is sufficiently powerful to sur-excite the nuclei of the facial nerve, and to cause contractions in muscles which no longer react to the voluntary impulses."

Guiffré goes so far as to compare tetanus to electrical stimulation, which is able to cause contractions of paralysed muscles.

In those cases in which there are only paralytic phenomena, it must be supposed that the tetanus toxin has remained localised at the periphery, and has not reached the nucleus of the facial nerve, or has not affected it sufficiently to excite the paralysed rami.

We have also mentioned, and this fact is recorded in a score of observations, and particularly in those of Charvot, Villar, and Réclus, that the contractions may occur on the opposite side to that affected by the facial paralysis. The result is a very remarkable facial asymmetry, which gives rise to the grimace known as the *risus sardonicus*, when the paralysed side assumes an expression of profound apathy, while the contracted side wears an expression of appalling fury (Poan de Sapincourt). This characteristic expression is peculiar to the tetanic infection.

The contractions may also become generalised ; cervical opisthotonus often accompanies cephalic tetanus. But if the infection gains ground the contractions may affect the trapezius, and the muscles of the back, abdomen, and limbs.

This extension is serious, above all when the pharynx, oesophagus, and diaphragm are in turn affected, as dysphagia may be caused, and consequently inanition and asphyxial symptoms.

5. Facial Paralysis.—Complete or incomplete, facial paralysis is never absent in this atypical form, although paralysis is extremely rare in the classic form of tetanus.

Commencement.—Facial paralysis is not always the first sign of the malady, and we have seen that trismus may precede it or co-exist with it. Nevertheless, it is an early symptom, which at once attracts the attention of those about the patient, and of the physician.

It is most frequent between the seventh and the twelfth day, but may appear, as we have remarked, at any time between the second and the twenty-fourth day of the disease. In cases likely to recover it tends to appear late, while in fatal cases it makes its appearance between the second and eighth days. Its early or late appearance may, therefore, be of prognostic significance.

Lastly, there is no fixed relation between its appearance and that of the trismus ; sometimes paralysis follows the latter ; sometimes it appears simultaneously ; sometimes it precedes it.

Situation.—As a rule the facial paralysis is observed on the same side as the wound in which the tetanic toxin is produced, and if the wound is median there is usually facial diplegia, either as an initial or as a late symptom.

Clinical Characters.—The facial paralysis occurring in cephalic tetanus recalls in every respect the ordinary paralysis of peripheral origin. Nevertheless, when the tetanic toxin has invaded the nervous centres, when the intraosseous portion of the facial nerve is injured, the paralysis presents the characteristics of a central paralysis of bulbar origin.

In the super-acute forms, moreover, it may resemble bulbar paralysis from the beginning, and in this case

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there is nothing surprising in the development of a paralysis of the side opposite to the wound.

This is a paralysis of a *toxi-infectious* nature, comparable to the paralysis of diphtheria.

(a) The type most frequently observed is *cephalic tetanus with complete peripheral facial paralysis*. Into this group fall those cases in which the paralysis affects one half of the face, and involves all the muscles innervated by the two branches of the peripheral facial nerve, the motor nerves of the muscles of the ossicles or the *chorda tympani* never being affected. Such cases present the type of the ordinary peripheral facial paralysis. In all the observations of these cases we find the signs of this affection are more or less fully recorded. There is exaggeration of the facial asymmetry by every movement, the disappearance of the *naso-labial furrow* on the affected side, and on the sound side there is incomplete closure of the lips, with dripping of saliva, and the nose is diverted to the sound side. The *ala nasi* on the paralysed side is no longer raised each time a fairly deep breath is taken, but, on the contrary, is flattened, and the nostril contracts, while the eye on the affected side can no longer be closed ; sometimes this gives rise to *epiphora* and *conjunctivitis*. The wrinkles of the forehead are effaced ; the *superciliary muscles* are immobile ; and the face is strange and expressionless.

Sweating on the affected side is found to be affected on application of the *pilocarpin test*.

In this complete form hearing and taste are unaffected, the soft palate is normal, and the uvula is not drawn to one side.

(b) In certain cases the superior facial nerve is unaffected, and consequently the superior facial muscles

are not involved. The eye may be closed, and the lines and wrinkles of the frontal region are not obliterated.

In this variety we have to deal with an incomplete facial paralysis involving the lower facial muscles, and this in turn may be divided into two categories, accordingly as the middle rami only or the inferior rami only of the facial nerve are affected. It is thus possible to define a middle inferior type and a pure inferior type, a good example of which is described by Crossonard. In this case, a wound of the lower lip, only the triangularis menti muscle was affected.

(c) Much more rarely, and quite as an exception, the toxin may spare the *inferior facial region*; we then have *cephalic tetanus of the superior facial type*. The eye is open, and the wrinkles of the forehead are effaced, but the muscles of the nose, lips, and chin are unaffected.

(d) Lastly, there are cases of *total facial paralysis*, no longer peripheral, but involving the muscles of the ossicles and of the chorda tympani. In these cases there is a toxic invasion of the petrosal portion of the facial nerve, which is manifested by disturbance of the hearing, taste, and smell. The observation recorded in 1902 by Lortat-Jacob is very interesting and instructive in this connection; the patient, who was ten years of age, had received a wound on the outer portion of the orbital rim of the left malar. On the eighth day cephalic tetanus made its appearance, with complete facial paralysis and disturbances of smell, taste, and hearing. Odours could not be perceived by the left nostril (the paralysed side). Taste was abolished on the same side; antipyrine, sulphate of quinine, and sugar (syrup) failed to produce any plainly different sensations, while taste and smell on the right-hand side remained unaffected.

A watch was heard at a distance of 30 centimetres

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on the right side, and at a distance of more than 40 centimetres on the left side, indicating some degree of hyperacusis on the injured side.

This fortunately rare form is far more serious than the preceding types ; it indicates, as a rule, a tendency to generalisation ; moreover, the paralysis itself is less readily recovered from.

Development and Prognosis

The facial paralysis usually remains localised during the whole term of the malady. It improves and tends to disappear simultaneously with the trismus, sometimes even before the latter (Oliva).

In certain cases, however, the paralysis has disappeared only when convalescence was reached, and it has even been known to persist after recovery from active tetanus.

As a rule, when the patient has recovered from tetanus the paralysis has disappeared. Its prognosis is, therefore, good, especially when its appearance is delayed.

Diagnosis of Facial Paralysis.—When the facial paralysis is the first sign of tetanus it is difficult to recognise its etiology, and the causes of error are numerous.

Paralysis of central origin is quickly eliminated ; with this there are other symptoms of a serious lesion.

Similarly, hystero-traumatic functional disorder, as the result of a wound in the head, might possibly produce somewhat similar symptoms ; but in this case the mode of onset, and the fact that the lower face is never exclusively affected, and above all the condition of paresis rather than paralysis, makes it totally unlike peripheral facial paralysis.

We may inquire, too, whether the paralysis may not be caused by a direct traumatic lesion of the facial nerve ; we may have to do with either a peripheral lesion of the nerve, a mistake easily made, considering the usual position of the wound, or a lesion of the intrapetrous portion due to fracture of the petrosa. The symptoms peculiar to this affection will rapidly establish the diagnosis.

Lastly, the physician may suspect a case of Bell's palsy, or disease of the middle ear.

Such a case may be accompanied by temporomaxillary arthritis and unilateral trismus, which render the diagnosis still more difficult. An examination of the auditory passage should always be made.

Pathogenesis.—Basing our remarks upon experimental data, the facial paralysis may be conceived as follows :— After a superficial infected wound in the territory of innervation served by the facial nerve, there is an absorption of toxin by the peripheral nerve branches in the neighbourhood of the wound, the toxin gradually reaching to the central neuron and the medulla, travelling solely along the nerves.

The infection may be localised, or may, on the contrary, spread along the cerebro-spinal axis. It follows that we may observe different forms of paralysis according to the degree of infection.

6. Fever.—Most writers regard apyrexia as one of the peculiar and constant characteristics of cephalic tetanus. There is frequently, however, a slight rise of temperature, and fever is almost always encountered when there are indications pointing to the invasion of the tetanic infection—that is, in serious cases. In the absence of such a rise of temperature the pulse must be consulted,

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for its great frequency is almost the rule in the facial form of tetanus.

Bacteriology.—In some cases of cephalic tetanus it has been possible to demonstrate the presence of Nicolaïer's bacillus, and even to cultivate it. It has even been possible to produce an experimental tetanus with local contractions (Lortat-Jacob). But in the tissues attacked by the tetanic toxin no discovery has been made of clearly defined lesions such as would explain the intensity and the gravity of the clinical indications observed.

Development, Duration, Prognosis.—As in the classical forms of tetanus, the development may be acute or sub-acute.

In two cases its duration did not exceed three days (two deaths); in fifteen cases it varied from five to ten days (fourteen deaths). In the other cases the tetanus was prolonged after the second week (one death and four recoveries).

The prognosis is thus to a certain extent dependent upon the progress of the disease, yet a case which by its early stages and its duration would lead us to expect rapid recovery may suddenly assume an acute development and end fatally. Similarly, a case regarded as mortal may terminate favourably.

The prognosis must accordingly always be reserved, whatever the course of development, or the apparent benignity or gravity of the symptoms, and although the prognosis is much less gloomy than in ordinary tetanus.

The mortality does not exceed 50 per cent.

Lastly, there are certain factors which may darken the prognosis.

Apart from the period of incubation, the progress of the malady, the degree of infection, and rapidity of

spread, the prognosis is also dependent upon the age of the individual, and his powers of resistance, and on an early diagnosis, which will permit of the speedy institution of a curative treatment.

Diagnosis.—Once typical symptoms have appeared they permit, as a rule, of a ready diagnosis. It must not, however, be supposed, because a wound in the trigeminal area is accompanied, at all events in the first place, by trismus of the same side, and by facial paralysis, that there is no room for hesitation as to the nature of the symptoms observed. Above all at the outset, when the three chief symptoms are not complete, certain affections may give rise to confusion, the more readily in that the wound may be cicatrised, insignificant, and occasionally forgotten by the patient, while the trismus may be slight, and unilateral, and facial paralysis may be late in appearing.

The tetanic infection may be unrecognised when the initial sign is merely a pain localised on one side of the face, or even a unilateral trismus. A direct traumatism of a branch of the facial nerve, the cutting of a wisdom-tooth, hysteria, dental caries, or cold may provoke the same objective manifestations.

Similarly, spasmodic facial neuralgia (*tic douloureux*) may give rise to analogous pains and contractions. These are frequently observed in certain cases of neuralgia of the trigeminal nerve. As a rule, there is a sudden contraction of the muscles innervated by the facial nerve on the side corresponding to the pain. This is, however, merely a motor reflex caused by the sudden pain experienced by the patient.

Lastly, the traumatic spasms described by Colles and Follin are differentiated only by the absence of Nicolaïer's bacillus.

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It is, however, probable (and we shall return to this point when examining the monoplegic partial forms of tetanus) that in many of the cases described by these writers they were in reality confronted by atypical and localised forms of tetanus.

However this may be, when we have to deal with a wound in the face which may have been contaminated by the soil, or by dust, or which contains a septic foreign body, and is accompanied by local contracture, or merely by facial asymmetry, the possibility of cephalic tetanus with facial paralysis must never be overlooked. In the absence of trismus it will always be necessary to investigate the case thoroughly from the clinical bacteriological aspect before rejecting the hypothesis of an atypical tetanic infection. By careful investigation we may sometimes recognise this special form of tetanus at the outset, and institute a treatment which will be the more efficacious as it is more promptly applied.

This serotherapeutic and symptomatic treatment will differ in no respect from the treatment adopted for other forms of the disease. We will only mention that the particular localisation of the infection has encouraged certain clinicians to administer injections of antitoxin near the place of inoculation, and for this purpose the lax cellular tissue of the cheek offers as great a facility to the needle as the skin of the thigh or the abdomen. Others have recommended the irrigation of the wound with antitetanic serum; it is possible that in this method, if the serum does not destroy the toxin, it may diminish its virulence and its rapidity of production.

One thing at least is certain, and we cannot lay too much stress upon it: that when confronted by an

excoriation or a wound of a suspicious character on the face (however slight or superficial it may be) we ought always to administer a preventive injection of anti-tetanic serum, which should be repeated a week later if any doubt persists as to the possibility of tetanus, and that the wounded subject will thus be protected from the risk of a delayed infection.

Cephalic Tetanus with Ophthalmoplegia

In addition to facial paralysis, cephalic tetanus may be accompanied by ophthalmoplegia, and Worms, in his thesis on the subject, has particularly examined this form.

History

The affection of the ocular muscles in cephalic tetanus long escaped the attention of medical writers. Hippocrates, Strümpel, Larrey, and Harkness had, it is true, mentioned the occurrence of ocular troubles during tetanus, but they did not attach any great importance to the fact. Only in 1882 did Wahl publish the first observation of tetanic ophthalmoplegia. Four years later Sereins mentioned a case of cephalic tetanus complicated by ptosis, and in 1890 Rocliffe described a further case accompanied by a double ptosis and diplopia. These observations were followed by those of Roberts and Williamson in 1891, and of Marx and Caird in 1893. Then, in 1894, Fromaget published an interesting memoir in the *Archives d'Ophthalmologie*, dealing with the ocular manifestations of tetanus. After the appearance of this memoir numerous observations were published, and Worms, in 1905, in his thesis upon "bulbo-paralytic"

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tetanus, described the clinical appearance of the particular atypical form which we are about to recapitulate here.

Etiology

As in the other forms, the cause of cephalic tetanus with ophthalmoplegia is the infection of a wound by the tetanus bacillus, and we may repeat here what we have already stated in connection with the preceding form as to the influence of such factors as the profession of the subject (carters, gardeners, farm labourers, etc., being particularly liable to infection), the nature of the traumatism, and the influence of the factors of age and sex (adult man).

A more important factor is the position of the wound, which is, in the majority of cases, a wound of the head, situated in the orbito-superciliary region, which, on account of its prominence, is frequently exposed to traumatisms.

The eyebrow is often involved. The skin of this region, on account of its anatomical situation, is exposed to the type of contused wounds favourable to the development of Nicolaïer's bacillus.

The eyelids are sometimes a site of infection when injured by cutting or stabbing instruments.

In several cases, those in which the tetanic ophthalmoplegia was most clearly defined, the trauma was in the eyeball.

As Worms has justly remarked, the eye, protected by the superciliary arch, and backed by a fatty cushion, would seem as though bound to escape tetanic infection. In these cases, however, the wounds were not caused by falling upon the face, but by projectiles (bullets, splinters of wood, whip-lashes) discharged so

suddenly that the sufferers were unable to protect the eyes.

It must not be supposed that tetanus occurring under such conditions is always complicated by ophthalmoplegia. The cases observed by Denuce and Chrisolm manifestly prove as much.

Lastly, when we have to deal simply with ptosis associated with paralysis of the face the position of the wound may be in the region of the cheekbone, the nose, the temporal region, or even in the mucous membrane of the buccal cavity.

A case is recorded in which the wound was in the right foot (Zack).

Clinical History

Initial Symptoms.—The ophthalmoplegia may on occasion be the first symptom of tetanus, apart from any other manifestation. This was the case in the observation published by Lépine and Sarvonat. In such cases it is only after the lapse of some days that the stiffness in the jaws and a slight amount of pain make their appearance. The patient experiences a difficulty in speaking, and very soon the stiffness passes into contractions and spasms of characteristic trismus.

The patient is then obliged to take to his bed, and the symptoms become aggravated. The face becomes contracted on the sound side and paralysed on the side of the lesion (*risus sardonicus*). The trismus becomes more and more intense and alimentation impossible. The muscular phenomena usually extend to the neck, the trunk, and the limbs, especially the lower limbs.

During this development the ophthalmoplegia persists, either unchanged or with certain modifications.

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One muscle, which was not involved, may become paralysed ; another, which was completely paralysed, may begin to act again ; the strabismus may increase or diminish (Worms).

If the ophthalmoplegia is localised in one eye, then toward the last days of the malady, or sometimes only during the terminal period, the sound eye is also affected.

Symptomatology. — The ophthalmoplegia in the observation published by Lépine and Sarvonat, which we have already described, was so definite that we may well describe it. In their patient paresis of all the muscles was observed, the eyelid falling and hiding the greater part of the cornea, and the patient, who had the appearance of being drowsy, threw the head back in his attempts to see from under the drooping lid. The forehead was wrinkled and the eyebrow lifted, in order to supplement the insufficiency of the levator palpebræ. Examining the movements of the eye, it was seen to be fixed in one position ; slight movements outwards only were observed, the right-hand external muscle being less paralysed than the rest.

In Marx's patient the ophthalmoplegia was of the external type—that is, there was paralysis of the external musculature of the eye, the internal musculature being unaffected.

In the case observed by Roberts and Williamson the ophthalmoplegia was bilateral, and established itself progressively ; the left eye, situated on the side of the wound, was the first affected ; it became immobile, the pupil moderately dilated and not reacting to light. On the following day the third and fourth pairs of cranial nerves on the right side became paralysed, and the pupil on that side was noticeably contracted.

In these cases the ophthalmoplegia was total from the outset. In other cases it was at first restricted to certain muscles.

Thus paralysis may involve the whole of the muscles innervated by the common oculomotor nerve, to the exclusion of the intrinsic musculature.

The signs of a paralysis of tetanic origin of the third pair of cranial nerves offer no special character to distinguish them from the signs of ophthalmoplegia of a different origin. It must be remembered, however, that when the paralysis is localised only in some of the muscles innervated by the third pair, the *levator palpebrae superioris* is almost invariably the muscle most frequently affected. However, in the case observed by Wahl there was paralysis of the two right-hand internal muscles (divergent bilateral strabismus).

The isolated paralysis of the levator is often partial, in the sense that the patient can slightly lift the upper eyelid ; but this movement must be differentiated from the lifting of the eyelid which may be effected by the compensatory action of the frontalis muscle. Occasionally the ptosis is the first manifestation of the paralysis. It is usually unilateral and most frequently situated on the same side as the wound, but it sometimes happens that the two levator muscles are simultaneously involved. Sometimes, as in Rocliffe's case, the ptosis is more accentuated on the side of the wound.

The paralysis of the sixth pair of cranial nerves is rarer, especially the isolated form. This form has been reported only on one occasion. It is usually observed in association with paralysis of the third and fourth pairs. Similarly, the isolated paralysis of the superior oblique is exceptional ; only one case is known. It is

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usually observed in conjunction with a paralysis of the oculomotor nerve.

The Situation of the Ophthalmoplegia.—As is the case with facial paralysis, ophthalmoplegia may be situated on the same side as the wound, but it is usually either bilateral from the first, or it invades the two ocular globes successively. Rarely the ptosis and ophthalmoplegia may make their appearance on the side opposite to the wound.

Pupillary Disorders.—Pupillary disorders may also be observed, either simultaneously with the paralysis or, more rarely, isolated.

These disorders have been noted by all the clinicians who have studied cephalic tetanus, and Albert, in his thesis, mentions that in this atypical form the sphincter of the iris is always contracted, and the pupil, greatly diminished, becomes pinpoint and does not react to light.

Possibly the condition of myosis present is due to the local action of the tetanic toxin on the sphincter of the iris.

It must be noted, however, that Jacobson has observed mydriasis in a case of cephalic tetanus. However this may be, in spite of myosis, accommodation is normal, at all events in the beginning, for later on the test becomes difficult. Moreover, Lépine and Sarvonat discovered that in their patient the iris dilated readily under the influence of atropine.

Amblyopia has also been noted (Larrey, Harkness), and according to Chevalier these amblyopic phenomena should be placed in the category of amblyopia due to intoxication without lesion of the fundus of the eye. But this is a pure hypothesis, for no ophthalmoscopic examination had been made. In those cases

in which it was possible to make such an examination, the fundus of the eye was found to be normal in four cases, and hyperæmic in the cases observed by Wahl, Fromaget, Lépine, and Sarvonat, but without other lesion.

Pathogenesis.—We shall not insist upon the different theories successively put forward in order to explain these forms of paralysis. We shall cite, as matters of historical interest, the asthenic theory advanced by Rose, and the reflex theory supported by Sereins and Houques, but the infectious theory alone appears to explain these special lesions. The experimental investigations of Brünner, Vaillard and Vincent have indeed demonstrated that the paralysis appears later than contraction, and is due to a greater virulence of the tetanic poison, or to the more prolonged action of this poison. Moreover, from the clinical point of view, the forms of cephalic tetanus which are accompanied by paralysis are particularly serious. Further, anatomical and pathological researches show that these forms of paralysis are not due to changes in the peripheral nerves, but rather to cellular lesions, and our clinical knowledge does not permit us to entertain the hypothesis of a neuritic origin. The ocular paralysis observed on the side opposite the wound can only be explained by a nuclear lesion—a theory which seems to receive general support—while the frequent occurrence of bilateral paralysis must also be due to the same mechanism. The habitual association of ocular paralysis with facial paralysis, the persistence of the pupillary reaction, the absence of blepharospasm, and the dissociated, incomplete type of the paralysis of the common oculomotor, recall the clinical features of nuclear ophthalmoplegia.

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This nuclear origin is further rendered probable by the presence of facial paralysis, which, in the majority of cases, is total, and which may be situated on the opposite side to the wound.

Finally, a last argument in favour of this origin is to be found in the fact that the ophthalmoplegia may be associated with a paralysis of the hypoglossal, and numerous autopsies have led to the discovery of lesions of the bulbar nuclei, especially in the region of the facial nerves.

According to Worms, these forms of ocular paralysis are the expression of a polioencephalitis, being analogous in this to post-diphtheritic paralysis.

As to the route followed by the toxin, if we go by the experimental researches of Courmont and Doyon, Marie and Morax, Meyer and Ransom, we may consider that paralysis of the cranial nerves may occur in two different ways, but it is difficult to assert that one mode of propagation is more probable than the other.

1. Through the medium of the trigeminal, lesions of which upon the face are of frequent occurrence. In wounds of the eyebrow, for example, the injured supraorbital nerve may lead the toxin to the oblongata, and the tetanic poison having infected the trigeminal, may gradually gain the nuclei of the motor nerves of the face and eyes, where it causes lesions which the microscope reveals with difficulty.

2. Through the medium of the motor nerves of the face (facial and common oculomotor). If the process is readily explicable in the case of facial paralysis, it is equally so in the case of ophthalmoplegia, if we suppose, with Duval and Mendel, that the fibres of the superior facial nerve which innervate the frontal muscles, the

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superciliary muscles, and the orbicular muscles of the eyelids, spring either from the external oculomotor nerve (Duval) or the common oculomotor nerve (Mendel).

If, on the other hand, we remember that in most cases of ophthalmoplegia the wound has been situated in the territory innervated by the third pair of cranial nerves, we may suppose that the toxin reaches the oblongata by way of a branch of the common oculomotor nerve. Finally, from the nucleus of the common oculomotor or its branches the toxin may reach the nuclei of the nerves of the opposite side.

Diagnosis.—The first question which presents itself in a case of cephalic tetanus with paralysis of the motor nerves of the eye is whether we are not confronted by a *false ophthalmoplegia*—that is, an apparent paralysis due to spasm of the ocular muscles. In this connection it is possible, as the result of a superficial examination, to confound the paralysis of the right external rectus with spasm of its antagonist, the right internal rectus.

To avoid this error Borel advises that the field of fixation should be determined by placing the eye at the centre of the perimeter, the head being immobilised. The sound eye is opened, while the affected eye is made to follow an object which is moved from the centre toward the periphery.

The field of fixation is normal in the case of spastic strabismus and limited in the case of paralytic strabismus. Borel has also discovered another means of differentiation in the graphic curve giving the excursion of the ocular movements. This curve should be contracted in the one case, and in the other case should assume a basin-like form.

In the spasm Parinaud notes supplementary con-

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tractions—*involuntary* blinking of the eyelids, fibrillary contractions of the orbicularis, a lack of co-ordination and an abnormal suddenness of muscular movements, and even nystagmus. Moreover, while, for instance, in paralysis of the right-hand external oblique adduction is normal, and abduction suppressed, in the spasm, as in the convergent strabismus, the movements are of normal extent and readily executed. Finally the spasms are *inconstant*, while the paralysis is fixed.

Once ophthalmoplegia is recognised its cause must be sought.

(a) If the patient does not furnish evidence of a previous wound or traumatism, we may, to begin with, consider the possibility of a meningeal lesion, and in particular a *cerebro-spinal meningitis*. As in ophthalmoplegic tetanus, we may, in fact, observe stiffness of the neck and ocular paralysis. But in this case we discover high fever (104° F.). Although partial tetani-form cramps may be present, there is no trismus, and the masseteric contraction can be partially or wholly overcome. Moreover, in tetanus Kernig's sign is absent; in many cases, for that matter, it would be impossible to look for it, on account of the intense muscular contractions. Lastly, a lumbar puncture, and the chemical, cytological, and bacteriological examination of the cephalo-rachidian fluid will enable us to remove any doubt.

The prodromal symptoms may also assist the diagnosis. Shivering, headache, and vomiting do not accompany the silent invasion of cephalic tetanus, and while the intellectual faculties are disordered in meningitis they remain unaffected in tetanus.

The form of *tubercular meningitis* in the adult,

described by Boix, commencing with isolated trismus, may simulate tetanus with paralysis of the motor nerves of the eye. The trismus is presently followed by stiffness of the neck, and sometimes by dorsal contractions, which do not facilitate a differential diagnosis. But in bacillary meningitis there are no convulsive spasms, and hesitation quickly disappears with the advent of the entire symptomatic train of the meningeal lesion : high temperature, modifications of the pulse, Kernig's sign, and the special character of the cerebro-spinal fluid.

(b) If the patient exhibits a wound resulting from a previous traumatism (a fall on the head or a violent blow in that region), accompanied by ocular paralysis, we may inquire whether the ophthalmoplegia is not due simply to a *fracture of the orbit*, a hypothesis all the more possible in that wounds inflicted by firearms are liable to involve the orbital region.

Considering the probability of tetanus, this is in general due to *superficial*, localised, and insignificant wounds, which do not permit us to suppose the existence of a considerable traumatism. In the contrary event we must consider the possibility of a *fracture* with intra-orbital haemorrhage, and the formation of a clot, which, according to its position and its dimensions, may give rise to a more or less complete immobility of the eye, thus simulating paralysis.

If the traumatism which has determined the wound on the face was of a certain severity, we may also pause to consider the possibility of a *fracture of the base of the skull*, with signs of compression. In such a case other and graver symptoms will be observed : stertor, disorders of movement, but no trismus ; all these signs, moreover, would appear at the time of the accident,

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while in tetanus there is a phase of incubation lasting for some days.

If ocular paralysis following upon a wound in the face cannot be explained by a *fracture*, if the subject is nervous, presenting all the signs of a functional neurosis, it is permissible to consider the possibility of an ocular manifestation of *hystero-traumatism*.

This will seem all the more possible inasmuch as under the influence of the trauma the hysterical manifestation develops in the neighbourhood of the wound, and because in this neurosis the phenomena of spasm and paralysis are very often associated.

Parinaud, examining the ocular derangements occurring in hysteria, has shown that apart from pseudo-paralytic ptosis the hysterical muscular disorders of vision are confined almost exclusively to modifications of the associated movements of the eyes. *Paralysis involves only the voluntary movements*; the eyes may move instinctively under the influence of numerous excitations which give rise to ocular movements without the direct intervention of the will.

Lastly, *hysterical ptosis* has individual signs which enable us to diagnose it; it is not permanent, and the eye is able to open when the attention is quickly engaged; it is often accompanied by photophobia; the eyebrow, instead of being greatly elevated, is, on the contrary, depressed.

The diagnosis of cephalic tetanus with ophthalmoplegia may be extremely difficult to establish.

The clinician, confronted by a wound of the face, *even an insignificant wound*, often cicatrised, accompanied by ocular paralysis, a slight facial asymmetry, and isolated contractions, should consider the possibility of tetanic infection. He will look for trismus, and

in the absence of this sign, if there is the least suspicion of a tetanic origin, he should immediately treat his patient accordingly, without waiting for the occasionally tardy appearance of confirmatory symptoms.

Prognosis.—Generally speaking, ocular paralysis is only of brief duration, and even in some fatal cases it has disappeared before death.

It disappears either simultaneously with the trismus and the facial paralysis, or after them.

The prognosis of the ophthalmoplegia, considered apart from the other tetanic symptoms, is good, since among the whole of the cases recorded only once has it persisted for as long as three months. At the end of this period Rocliffe's patient still exhibited diplopia and a slight ptosis in the left eye.

If the prognosis is difficult to establish positively, as we have only a limited number of observations to go by, it is nevertheless noticeable that those cases in which ophthalmoplegia has been very definitely manifested have had a fatal termination.

In order to give a prognosis we must take into account the muscular contractions, the temperature, the respiration, and above all the duration and the time of the first appearance of the tetanus. Putting aside the unforeseen complications which may supervene, we may say that chronicity is a factor of recovery ; the duration of those cases which have recovered has varied from four to twelve weeks (average, seven weeks).

The prognosis is more serious in proportion as the tetanus makes its first appearance at an earlier date. Thus, in the fatal case observed by Lépine and Sarvonat, the period of incubation was five days.

This, by the way, is a prognostic factor common to all forms of tetanus infection.

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The treatment of this variety is that of ordinary tetanus. We will only remark that if the ophthalmoplegia persists after the evolution of the tetanus is terminated we may employ local electrical treatment and strychnine, as for facial paralysis.

Cephalic Tetanus with Paralysis of the Hypoglossal

In the course of cephalic tetanus we may observe, in association with facial paralysis and ophthalmoplegia, a paralysis of the hypoglossal. Such observations are exceptional. Their principal interest resides in the fact that from the pathogenic point of view they argue in favour of the nuclear origin of the forms of paralysis occurring in cephalic tetanus. Clinically speaking, the invasion of the hypoglossal determines a syndrome of labio-glosso-laryngeal paralysis.

The different forms of paralysis which characterise each variety of cephalic tetanus are often found to be associated in the same patient, and there is a particular clinical type, that of Rose's "cephalic tetanus," which is characterised by three essential signs :

1. Contractions localised in the cervico-facial region.
2. The existence of facial paralysis which may attack the facial nerve, the motor nerves of the eye, and the hypoglossal.
3. An essentially chronic development, without fever, the general condition being unaffected.

We may therefore resume the symptomatology of cephalic tetanus in a fairly simple fashion : the patient complains that he cannot open his mouth, and experiences the greatest difficulty in swallowing food ; whence trismus and dysphagia. The symptoms may go no

further than this (dysphagic and hydrophobic forms). But in general the patient exhibits a more or less accentuated facial paralysis, a paralysis affecting the wounded side, a paralysis sometimes difficult to discover when there is contraction of the muscles of the opposite side of the face (Binet and Trenel). To determine whether it actually exists it is enough to instruct the patient to make an effort to open his lips or his eyelids. If he cannot do this in that part of the face which is immobile and inert, there is really paralysis of the seventh pair of cranial nerves. This is the facial form of cephalic tetanus.

Occasionally signs of ophthalmoplegia associated with facial paralysis make their appearance, dominating the clinical picture (Worms' bulbo-paralytic form). There is sometimes paralysis of the sixth pair of cranial nerves, sometimes of the fourth pair; but most frequently it is the common oculomotor which is involved. If the lesion involves only some of its fibres a greatly localised paralysis results, affecting either the levator palpebrae superioris, causing ptosis, or the motor muscles of the eye, giving rise to strabismus, or the internal musculature, causing loss of accommodation and possibly explaining the amblyopic phenomena observed in certain patients. These ophthalmoplegic phenomena may appear before the facial paralysis, the ptosis becoming the first indication of cephalic tetanus. Lastly, the hypoglossal may be affected, with the labio-glosso-laryngeal syndrome predominant (fourth form of cephalic tetanus).

Unilateral Tetanus

We do not believe that there is such a thing as unilateral tetanus characterised by the sole and exclusive

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localisation of the contractions to one side of the body. These are simply cases in which the tetanic symptoms persist for a long time on one side of the body only, and remain very predominant on that side during the period of generalisation, giving rise to pleurothonotos.

Properly speaking, there is here no question of an atypical form, so we shall content ourselves with the mention of this particular variety of the tetanic infection.

PART II.—LOCAL TETANUS OF THE LIMBS

CHAPTER I

OBSERVATIONS

WE shall eliminate from this variety of tetanus the cases observed by Esau, Boinet and Monges, and Curtillet and Lombard, in which the tetanic infection was not localised in the initial seat of infection during the entire development of the disease. In Esau's observation, entitled *Local tetanus of the hand*, the malady, despite the title, was local only during a first period ; contractures developed in the left upper limb seven days after a traumatism of the left hand ; but nine days after their appearance trismus and opisthonotos appeared, thus completing the clinical picture of a classical case of tetanus, subacute in form, predominant on the left. Similarly, the patient observed by Boinet and Monges had received a knife-wound in the left supraspinous fossa. Five days later tetanus set in, with contractures in the left superior member, and these contractures remained localised for a week ; but at the end of this period they invaded the muscles of the neck and face, the right upper limb and the lower limbs remaining unaffected. Lastly, in the case reported by Curtillet and Lombard the malady was once again rather an incomplete tetanus, monoplegic to begin with, then a local tetanus, for the contractures, at first confined to the

wounded upper limb, invaded the muscles of the chest and neck.

The different observations which we are about to reproduce here fall, on the other hand, under the heading of local tetanus, *as in these cases there was never any trace of generalisation*. The cases observed by Pozzi, Routier, Laval, Monod, Carnot and ourselves are peculiarly typical, and enable us to sketch the clinical history of this peculiar local form. We have no intention of bringing together all the published observations of atypical tetanus of the limbs, but only those which appear to us to be particularly interesting, and which will enable us to describe the clinical development of local tetanus of the limbs.

Observation I. (Courtellemont).—Tetanus confined to the left-hand lower limb

C——, sixty years of age, usually enjoyed good health ; his antecedents were not in any way remarkable. Towards the end of July, 1909, while working in his garden, he slightly wounded his left foot with the tooth of a rake. He attended to the small wound, which in appearance was insignificant, and in a few days it was healed. On Wednesday, the 11th of August, or about fifteen days after the accident, the left foot became slightly heavy, stiff, and extended at the ankle joint in the position of a talipes equinus ; at the same time there was an incomplete trismus. On the next day and up to the 15th August these sensations and this deformation of the foot became more accentuated, without any modification of the trismus.

During the whole of this first period the disorders consisted of a slight trismus and contractures involving the left leg, a trace of the affection in the neck and trunk, and abundant sweats. The trismus never amounted to absolute closing of the jaws ; it went no further than making it impossible for the patient to open his mouth completely. It was permanent, and exaggerated by a spasm on the approach

of food. The subject also found it extremely difficult to eat, being unable to masticate.

In the left lower limb there was a permanent contracture, and painful paroxysms were localised in the foot and the leg. The foot was fixed in the position of talipes equinus, the toes were flexed and the contracted calf formed a hard mass. In this condition, intermittent intensifications of the contractures occurred. These paroxysms were very painful; they occurred as the result of a sudden noise (the ringing of a bell, for example), or of movements (when the patient turned in his bed or tried to raise himself). The threat of generalisation showed itself at the moment of these intensified contractures of the left foot and leg; indeed, when the paroxysms were violent the whole body seemed to feel the effect. The trismus increased, the trunk became stiff, and the three remaining limbs also possibly exhibited a slight stiffness, but the patient could not be positive of this last point. On Sunday, the 15th August, Dr Hurtel found the patient lying on his back, incapable of sitting up on account of the stiffness of the trunk, the paroxysms being excited by every attempt to stand up or sit down.

Dr Hurtel diagnosed tetanus, prescribed absolute repose, and darkness, and administered chloral (3 to 8 grammes daily, according to the intensity of the paroxysms). By the evening, and on the following day, the 16th, the condition of the patient had improved, the trismus was attenuated, and all trace of generalisation had disappeared, but the condition of the left leg remained much the same.

We saw the patient on the 17th August. He was in bed, the left lower limb lying abducted, the lower leg half-flexed at the knee; the foot was in hyper-extension—that is, stretched out like a horse's foot—and this attitude appeared to be pushed to the maximum degree; the five toes were strongly flexed. All the muscles of the leg were contractured; they were hard; the relief of the soleus and the twin muscles of the calf was greatly accentuated, the appearance being extremely striking. There was extreme contracture of the muscles of the leg and foot, most marked in the muscles of the calf. This contracture was permanent. It was impossible to modify the attitude of the foot, but the knee could be completely straightened; the hip was mobile, and the thigh could be flexed upon the pelvis, although it

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offered a little resistance. Owing to the condition of the foot the patient could not sit down, save on the edge of the bed with the leg pendent. There were no contractures of the muscles of the back or neck, and no trismus.

Sometimes, when the patient made a movement, a painful cramp occurred in the left leg and foot; this was a paroxysm confined to these two regions.

The patient was cheerful, speaking with ease. He presented no sign of visceral lesion.

We administered an epidural injection of 10 c.c. of antitetanic serum, and prescribed chloral, in doses of 6 to 8 grammes in the twenty-four hours. The following week went by without aggravation, but without notable improvement, the symptoms remaining entirely confined to the left leg and foot, and there were, rarely, slight paroxysms, also confined to the same regions. During this time the physician in charge of the case administered three subcutaneous injections of 10 c.c. of antitetanic serum.

On the 23rd the dose of chloral was decreased to 3 or 4 grammes; the following night an aggravation of the disorders appeared; numerous and painful cramps of the left leg, a few attacks of cramp in the right leg, some abdominal colics, and some lumbar pains due to spasmodic contracture of the muscles in that region.

On the morning of the 24th the right leg was slightly stiff, and the dose of chloral was immediately increased. In the afternoon the right leg was again normal, but the lower portion of the abdominal wall was rather hard; apart from this sign the disorders were still strictly localised in the left leg and foot. However, the spasmodic intensifications and the cramps were slightly more frequent than on the occasion of our first consultation; we produced them, in particular, by seeking to correct the equinism.

A fresh epidural injection of 10 c.c. of antitetanic serum was administered. From this moment the improvement became progressive; but the patient retained for some six weeks a stiffness of the left foot and leg, and he could not place the foot on the ground without experiencing a painful cramp. Complete recovery was not accomplished until after this long period had elapsed.

Observation II. (S. Pozzi).—Localised tetanus (early)

H——, a soldier wounded on the 25th September 1915, near Souchez, by shell-splinters which traversed and splintered the bones of the left-hand tarsal region; the wounded man was given his first dressing on the 25th September, four hours after being wounded, at the advanced dressing station; he received his second dressing on the 28th, or three days after he was wounded, at Aubigny; on the evening of the 29th he reached Broca, where a third dressing was applied (iodoform gauze).

The preventive injection of antitetanic serum (10 c.c.) was administered on the 28th—that is, three days after the patient was wounded. On examination, on the 29th, it was discovered that the two wounds of entry and emergence were exuding a little pus. There was no oedema of the foot. The pain in the region of the wound was not very severe. The general condition appeared to be good. The rectal temperature did not exceed 98·2° F.

On the 30th September a drain was passed through the wound, seton-wise. During the day the pain in the region of the wound increased; then a few convulsive jerks occurred, solely in the left leg, succeeding one another at a few minutes' interval. These jerks were very painful, and attained their maximum when the slightest movement was made.

There was no contracture or cramp in any other part of the body; no trace of trismus. In the evening the temperature reached 100·4° F.

From the 1st to the 4th of October the pain arising from the convulsions increased each day. The jerks occurred with shorter intervals, and became more violent in the left leg and thigh. The temperature rose to 104°.

On the 5th October an extensive opening up of the wounds was effected. The course of the wound was explored, and a few free splinters of bone were withdrawn. On the evening after the operation the temperature rose to 104·7° F.

On the 6th October the temperature dropped a little, but the convulsive jerks became extremely frequent. Every ten seconds the whole of the wounded limb was the seat of the most excruciatingly painful contractions; towards the close of the day a few slight jerks occurred in the right leg.

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No spasm existed as yet in the region of the upper limbs ; and there was no trace of trismus or contracture of the trunk muscles. This day the second preventive injection of 10 c.c. of antitetanic serum was made.

On the 7th the convulsive jerks increased in frequency and in violence, especially on the wounded side. They continued, though much less violent, on the right side. The patient was screaming with pain, and could be calmed neither by morphia, nor pantopon, nor large doses of chloral.

The evening temperature was 104·9° F.

On the morning of the 8th there was no remission of the jerks. The left-hand lower limb was contractured, the calf being slightly flexed on the thigh and the thigh on the pelvis.

Locally, the cicatrisation of the wounds was not progressing. The suppuration had slightly diminished, but there was no progress toward healing.

The temperature being 103·6° F., and the pains atrocious, it was decided that amputation should be performed ; the patient insistently demanded it. It was hoped thereby to arrest the nervous symptoms by abolishing their point of departure.

Supramalleolar amputation was performed ; no sutures being applied.

Operative Sequelæ.—During the days following the operation the temperature fell, becoming normal on the 10th, or the second day after the operation. The operative wound presented a most favourable appearance.

As for the convulsive jerks, they had diminished neither in frequency nor in violence. On the contrary, the pains were so violent that the wounded man had not a moment's repose ; he knelt in his bed, seeking a less painful position. The jerks were as marked on the right side as on the left for two days ; then they diminished on the sound side, and finally disappeared entirely. The wounded side was contractured, the limbs being flexed. The pain was more violent when an attempt was made to extend the limb.

No therapeutic agent could overcome the pain. Morphia, large doses of bromide of potassium (8 to 12 grammes daily), pantopon, and extract of valerian were employed, and an application of radium was made without success. Only the bromide and the pantopon gave a little relief. The bromide

was continued for ten days; the pantopon was continued until the end of October.

The jerks and pains then became less violent. But the contracture increased; the flexion of the calf upon the thigh was most pronounced.

There was no trophic trouble in the lower legs.

Following the advice given by Dr Veillon, Director of the Laboratory at the *Clinique Infantile des Enfants Malades*, massive and successive injections of antitetanic serum were administered :

23 October	:	.	.	.	.	.	.	.	.	.	.	.	40 c.c.
24 October	:	.	.	.	.	.	.	.	.	.	.	.	40 ,,
25 October	:	.	.	.	.	.	.	.	.	.	.	.	20 ,,

This active treatment did not appear to produce any marked change. From the 25th October to the 30th the jerks progressively diminished in frequency and violence, and were of rare occurrence, but the contracture was maintained.

Locally, the cicatrisation of the stump proceeded normally. To remedy the persistent contractures subcutaneous injections of perphoxene were tried on the 1st and 2nd of November. The pain caused by the injection rendered it intolerable to the patient, who, however, had at this time already exhibited a remission.

On the 6th November the pains momentarily reappeared in the left limb, with a few jerks. The right limb was thenceforth unaffected. The same day, as a sedative, bromide of codein was tried, in subcutaneous injection, the dose being 0·02 grammes per injection. The patient appeared to be relieved by this, and was able to sleep better than after the other sedatives.

After the first painful period, the patient passed through a period of permanent contracture without pain. On the 7th December his left lower leg remained flexed at right angles to the thigh, owing to the powerful contracture of the flexora of the knee, the strained tendons of which could be felt by the finger in the popliteal region. There was also a slight contracture of the adductor muscles. Complete extension of the leg was therefore absolutely impossible; moreover, the gastrocnemius was hard and rigid as a lump of wood.

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Pressure, unless it was exaggerated, was not painful in the region of this muscle, nor in the region of the thigh muscles. It resulted, from this permanent contracture of the muscles, that the patient was not yet able to benefit by an appliance which would enable him to walk without crutches.

The considerable improvement which has for some days been observed under the influence of massage gives reason to hope that the contracture will presently cease entirely, before the onset of muscular atrophy.

This observation is that of a localised tetanus intermediate between the monoplegic type (predominant) and the paraplegic type, which was established only for a few days, thereupon disappearing without leaving any traces.

Observation III. (Ch. Monod).—Localised tetanus of the right arm

Joseph-Marie Le Br——, thirty years of age, a sergeant in the 8th Battalion of Chasseurs à Pied, wounded, on the 25th September 1915, at Auberive, entered Auxiliary Hospital No. 35 on the 29th September.

First dressing, seventeen hours after the wound; first antitetanic injection, the 27th of September, fifty hours after the wound.

Diagnosis.—Wound caused by a bullet fired from a distance of eight yards. Orifice of entry, small, on the posterior face of the right arm. Enormous wound of emergence occupying almost the whole anterior portion of the forearm. Second orifice a little below the first. The two orifices were drained.

Progress of Malady.—29th September. Temperature, $102\cdot75^{\circ}$ - $104\cdot4^{\circ}$ F.

Moist dressing with Labarraque's solution. Drainage.

1st October.—Temperature, $103\cdot7^{\circ}$ - $102\cdot2^{\circ}$ F. A patch of total gangrene (skin and muscles) extending to the anterior internal face of the forearm, having commenced with an isolated black spot above the wrist. Extensive cleansing with thermocautery was carried as far as the bone, without anywhere finding a sound muscle. On puncture with thermocautery, there was an obvious escape of gases. Moist dressing (Labarraque's solution).

3rd October.—Temperature 101·6°-102·7° F. The gangrene has extended to the hand. Same treatment, serum, electrargol applied. Patient suffering greatly.

4th October.—Temperature, 101·6°-99·1° F. Circular amputation of the upper arm in its middle portion.

5th, 6th, 7th October.—Temperature, 100·4°-101·1°, 99·7°-100·2°, 98·2°-99·1°, F.

8th October.—Patient gets up. Suffers little pain.

9th October.—Shooting pains in the stump, the pains increase during the night. Temperature, 98·2°-98·2° F.

10th October.—Temperature, 97·9°-99·7° F. Very violent jerks in the stump and shoulder, recurring sometimes every three or four minutes, and forcing a cry from the wounded man. These jerks are not clonic but tonic, the member being convulsively drawn toward the trunk. Morphia.

11th October.—Temperature, 100·2°-100·2°. Threads removed prematurely under ether. Carbolic acid, 5 per cent. solution, sprayed over the stump. Chloral, 2 grammes. Antitetanic injection (the first since that given at the outset, fifty hours after the wound). About five hours later the jerks diminished; the patient was greatly relieved. The spraying was discontinued.

12th October.—Temperature, 100·2°-102·6° F.

13th October.—Temperature, 99·7°-103·6° F. The patient still suffering a little; slight contractions.

15th October.—Temperature, 98·9°-100·4° F. At 2 P.M., 3 P.M., and 5.30 P.M., tetaniform paroxysms, with stiffness of the neck and hardening of facial muscles. The hand contracts like a claw, and is slowly drawn towards the right armpit; the head is violently thrown back. The patient loses consciousness. Returns to consciousness at the end of five minutes, but cannot at first speak, and does not understand what is said to him. He is dripping with perspiration. At the end of a quarter of an hour he has fully recovered consciousness, and the slight paroxysms recommence as before.

The patient explains that at the moment of the paroxysm it seemed as though someone seized his arms and forced him to whirl them violently round like the sails of a windmill. Excruciating pain. The same symptoms are exactly reproduced in all three paroxysms. As soon as he comes to himself the patient has no difficulty in opening his mouth

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to its full extent and in swallowing. The patient is isolated. Six grammes of chloral.

16th October.—Contractures not quite so painful in the wounded arm. Chloral, 8 grammes; subcutaneous injection of 10 c.c. of sulphate of magnesia, according to the formula:

Sulphate of magnesia crystallised with 7 molecules of water of crystallisation	250 grammes
Distilled water	1000 ,,

During the night the jerks become very painful and force cries from the patient every two or three minutes.

A fresh injection of sulphate of magnesia.

The patient becomes quiet, and sleeps.

17th October.—Jerks still painful and very frequent. Eight grammes chloral. Three injections of sulphate of magnesia.

18th October.—Same condition. Chloral, 8 grammes. Three injections of sulphate of magnesia.

19th October.—Jerks less painful, and sometimes occurring at intervals of several hours only. Chloral, 4 grammes. Two injections of sulphate of magnesia.

20th October.—Improvement continues. Six grammes chloral. Two injections of sulphate of magnesia.

21st October.—Second antitetanic injection. Six grammes chloral. Two injections of sulphate of magnesia.

Before the injection of serum the patient had two paroxysms at which no one was present. He says he did not lose consciousness, and that the paroxysms were less violent than those of the 15th October, just a week earlier. He was next seen dripping with perspiration, and for a time the pain disappeared. After the injection a fresh crisis at a time when the patient was alone.

22nd October.—Two slight paroxysms in the morning. Seven grammes chloral. Three injections of sulphate of magnesia.

23rd October.—Greatly exhausted. Suffering greatly. Six grammes chloral. Three injections of sulphate of magnesia.

24th October.—Third antitetanic injection. Six grammes chloral. Three injections of sulphate of magnesia.

25th October.—Quieter. Fourth antitetanic injection. Six grammes chloral. Three injections of sulphate of magnesia.

26th October.—Fifth antitetanic injection. Six grammes chloral. Three injections of sulphate of magnesia.

27th October.—Sixth antitetanic injection. Four grammes chloral. Three injections of sulphate of magnesia.

In the morning one injection of sulphate of magnesia is given. The patient appearing better, it is decided to stop these injections and to diminish the chloral. But the pains having recurred with great violence towards the evening, with cries at each jerk, two injections are given close together (8 and 8.30 P.M.). The night is quiet.

28th October.—Patient much better. Four grammes chloral. Patient joking. Often goes several hours without jerks. They are slight and not very painful.

2nd November.—Eighth antitetanic injection.

8th November.—The patient no longer has violent jerks, except in the morning, when his bed is approached. If one calls him, even gently, he wakes with a start, uttering a cry. The arm remains painful.

9th November.—Ninth antitetanic injection. Wound almost entirely cicatrised. Temperature oscillates henceforth between 98° and 99·5°.

20th November.—The patient is completely cured.

Observation IV. (Routier).—Abnormal localised tetanus

On the 18th May 1915 a wounded man came under my care for a penetrating wound of the upper and posterior region of the thorax, on the left, with pleural effusion.

Wounded a few days before, he had been given an injection of antitetanic serum.

On his arrival the patient appeared greatly prostrated; there was abundant suppuration, with high temperature. On the following day, the 19th, the countenance was anxious. The patient complained of sharp pains in the left arm, and temperature was 104° F.

This grave condition was not modified on the 20th, but on the 21st the left arm, still the seat of violent pains, was animated by involuntary movements, by incessant clonic contractions.

The forearm flexed itself suddenly upon the upper

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arm, while the latter was thrown violently forwards and outwards.

The wrist and fingers remained unaffected. The pain was violent, and the movements continuous, with exacerbations occurring in paroxysms.

Much puzzled to explain these pains and spasmodic movements, I begged my colleague and friend, Babinski, to come and give me his opinion. After a very careful examination Babinski confirmed our apprehensions, affirming that this was indeed a case of abnormal tetanus, and added that its termination would probably be fatal. On the following day, in fact, we observed trismus, pleurothonotos, and then stiffness of the neck.

The pulse quickly became very variable, sometimes being almost normal, and sometimes very rapid, while the respiration assumed a jerky character. At the onset of the accidents we administered a fresh injection of antitetanic serum, and gave the patient, who was isolated, 10 grammes of chloral per diem with morphia at night. This treatment, continued day by day, did not abolish the paroxysms. The patient died of asphyxia on 3rd June.

Observation V. (Routier)

A naval sub-lieutenant was wounded on 25th September in the right scapular region, by a large shell-splinter. Dressed at the Quatre-Vents field hospital, the wound was opened up, and a large haematoma evacuated which made, as it were, a fistula in the posterior portion of the upper arm; and two drains were placed in it. An antitetanic injection was said to have been given on the 26th, twenty-four hours after the wound.

The patient was evacuated to Necker, with a large suppurating wound in the right scapular region, but it had a very good aspect, with two orifices near the bottom.

The patient was not suffering, complaining only of the weight of his arm. The general condition was excellent; the temperature on the first evening was 100·4° F, but on the following day it became normal.

Treatment was confined to dressings every second day, moistened with a solution of chloride of magnesium.

He was in such good condition that I authorised his evacuation into the country, but this was not effected.

On the 8th October the patient complained suddenly of a very severe pain in the right thigh. Nothing visible. Temperature, $98\cdot6^{\circ}$ F. in the morning; $99\cdot5^{\circ}$ F. in the evening.

On the 9th the pain in the right thigh became intolerable. The muscles were slightly contractured; there was marked adductor spasm. Violent headache during the day; slight stiffness of the neck; exaggeration of the reflexes of the whole of the right lower limb with epileptiform spasms. Temperature, $99\cdot7^{\circ}$ F. in the morning; $101\cdot3^{\circ}$ F. in the evening. Isolation and 10 grammes of chloral ordered.

On the 10th the pains persisted with paroxysmal crises; the stiffness of the back of the neck was more marked. There was also lumbar stiffness. The patient was very nervous; he had photophobia: he complained the moment anyone made the slightest sound or directly one approached him. Morning temperature, $100\cdot4^{\circ}$; evening, $101\cdot3^{\circ}$. The wound seemed to be doing well. Ten grammes of chloral and two subcutaneous injections of a solution of calcium hypophosphate and sodium persulphate.

On the 11th the same signs, with the addition of a slight trismus. Morning temperature, $101\cdot3^{\circ}$ F.; evening, $102\cdot2^{\circ}$ F. Ten grammes chloral and three injections.

The tongue was dry; the patient drank but little.

This same condition continued, and we pursued the same treatment until the 15th October. The temperature then fell to $99\cdot7^{\circ}$ F. The phenomena of contracture and the pains amended; despite this 10 grammes of chloral was given, and the subcutaneous injections were reduced to two, then to one, until the 13th October; the patient still had a few cramps in the back of the neck; finally, on the 22nd, all seemed to become normal once more, and all danger was averted.

The painful phenomena were predominant. There were also contractures chiefly affecting the adductors of the thigh, and a slight trismus and stiffness of the muscles of the back of the neck, but if a very close watch had not been kept these indications might have been unnoticed at the time of their commencement.

Observation VI. (Routier)

M. G——, wounded on the 25th September, entered the hospital at Necker on the 30th. He had a compound fracture of the left elbow, and a wound on the left hip, both being in good condition. Everything seemed as though destined to advance toward recovery when, on the 17th October, the patient exhibited a very painful contracture of the whole of the left lower limb, the thigh being flexed up on the pelvis, the lower leg flexed at the knee-joint; the toes were strongly flexed; all the muscles were rigid. The limb was like wood. The reflexes were exaggerated, with epileptiform twitching. Slight pain in the neck, without stiffness; no trismus; the temperature, which since the 8th October had been normal, rose to 102.6° F.

The patient was isolated. Ten grammes of chloral and two injections of the solution as in the previous case. The same symptoms persisting on the 18th and 19th, I prescribed the addition of an injection of morphia every night.

On the 21st the contracture of the toes appeared to be yielding.

On the 22nd the contracture of the entire limb was no longer continuous.

We observed alternative contraction and flaccidity of the muscles. Vomiting in the night. Parched tongue.

On the 23rd the contracture was greatly diminished. The tongue remained parched; intense thirst.

On the 24th the patient died in the night.

Observation VII. (Routier)

A soldier of the 8th Colonial Regiment was wounded on the 25th September, and entered the Necker hospital on the 15th October. He had two wounds (each with two orifices), one in the upper portion of each thigh, and a slight wound of the perineum, due perhaps to the same projectile, which had not remained in the wounds. When receiving first aid he had been given an antitetanic injection.

Everything appeared sufficiently benign. On the 26th October the patient suddenly complained of pains in the

right knee, which was neither red nor swollen; the lower leg was strongly flexed up at the knee. The patient refused to stretch it out, and cried out when attempting to extend it.

On the 27th the flexion was reduced. The leg was placed on a Bœckel splint. Four grammes salicylate of sodium.

The temperature, which until then had oscillated between 98·6° and 100·4° F., rose to 104° in the morning, and registered 100·2° F. at night. The facial aspect argued in favour of typhoid fever, but the sero-diagnosis was negative.

On the 28th the Bœckel splint was removed, as it could be no longer borne; immediately the leg flexed itself forcibly at the hip and knee joints.

The muscles of the abdominal wall contracted in turn, and during the day contraction of the left arm was noted. On the 29th, 30th, and 31st October all these signs increased; one could no longer approach the patient without his crying out.

Isolation of patient. Ten grammes chloral. Three injections of the solution already mentioned.

Treatment continued until the 5th November, when the chloral was discontinued, the patient showing symptoms of poisoning.

On the following day 6 grammes of chloral was given, per rectum, but it was not retained. The patient was developing a sacral bedsore. Pain still violent, and the contracture of the adductors of the thigh very marked.

During this contracture of the muscles of the leg the foot always remained mobile and supple.

On the 10th November, 6 grammes of chloral was given on account of the greater violence of the pains.

On the 11th the patient could extend his right leg, using his left foot for the purpose, pushing his right foot with it.

On the 13th the chloral and subcutaneous injections were discontinued; they had been continued without interruption from the beginning, to the number of three per diem.

On the 15th the pains and the contracture reappeared. The 6 grammes of chloral and the three subcutaneous injections were resumed.

On the 16th the pains and contractures had ceased. However, the treatment was continued.

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The chloral was stopped on the 17th; the injections on the 18th.

The patient is recovering.

Observation VIII. (Routier)

A soldier, thirty-three years of age, wounded at Souchez on the 24th September, entered Hospital 106 on the 1st October, having been given one antitetanic injection.

He had a wound in the head, in the right frontal region, without fractures, numerous wounds of the left upper limb, the shoulder, and the forearm. Many wounds in the two thighs.

A few days after his arrival, pleural effusion on the left side.

16th November.—Pleurotomy with costal resection. Enormous evacuation of pus.

17th November.—Pains and muscular twitchings of the whole of the left lower limb. Permanent contracture in extension.

Reflexes greatly exaggerated on the left; normal on the right.

18th November.—Disappearance of the muscular twitchings.

19th November.—Contracture diminished.

The same signs persisted until the 26th.

The contracture no longer appeared save on the occasion of a voluntary movement.

30th November.—This day the movements of flexion were still effected slowly, and were preceded by a contracture of all the muscles of the right lower limb, which disappeared when the limb was flexed.

From the commencement of the spasms the patient was isolated and subjected to treatment by chloral, 6 grammes daily, morphia, and subcutaneous injections of Bottu's solution.

All treatment was discontinued on the 26th; the patient had recovered.

Observation IX. (Laval).—Tetanus localised in one leg

André M.—, of the— Regiment of Infantry, twenty-three years of age, entered the hospital on the 13th April, at

11 A.M. He had been wounded two days earlier, on the 11th, at Les Éparges, by shell-splinters.

Dressed for the first time a quarter of an hour later, on the spot, he received a second dressing at the temporary field hospital at 7 P.M.; and a third on the following day, the 12th, at 4 A.M. Finally, a fourth and last dressing was administered at 2 P.M. at Verdun. There, it was stated, a shell-splinter was extracted from the wound in his chest.

No antitetanic injection.

M—, being examined on the 13th April, presented a wound of the left lower region of the sternum, apparently superficial, and a perforating wound of the left lower leg, the orifice of entry at the juncture of the lower third and the middle third, the orifice of emergence three-fingers'-breadth below the mid-line of the knee-joint.

General anaesthesia by ethyl chloride; the orifices of entrance and emergence of the shell-splinters in the lower leg were enlarged. The wound was cleaned out with hypochlorite solution, 4 per cent.

Moist dressing. Immediately afterwards an injection of 10 c.c. of antitetanic serum was given.

The fever gradually decreasing day by day, and the local condition appearing to improve at the same time, the treatment was confined to the daily cleaning of the wounds with hypochlorite solution until the 19th April.

From this date the clinical picture underwent a transformation. Even on the day before the patient had complained of feeling violent pains in the wounded leg. On the 19th he was examined by X-rays, when a foreign body of some size was discovered in the antero-external region of the lower leg, in its middle third. The two orifices, therefore, did not correspond with the orifices of entry and emergence of one projectile; there was no single perforating wound, but two distinct wounds, one of which still retained the foreign body which had caused it; the other perhaps was a surgical wound.

An hour later, under chloroform, an incision was made in the direction of the anterior tibial artery, five-fingers'-breadth below the wound. Under the superficial aponeurosis, after the separation of the tibialis anticus, fetid gases and yellowish-red pus escaped from the depth of the tissues.

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The finger being introduced withdrew a fragment of a shell from the inter-osseous region; this was situated on its anterior aspect. In the depth of the cavity from which this was extracted the forefinger discovered and withdrew a wad of debris from the patient's clothing, the total volume being that of a small nut.

The wound was cleaned with Javal's solution.

Drainage.—The temperature was normal. The question of evacuation was about to be considered, when on the morning of the 23rd there was a fresh surprise: the lower limb was strongly contractured in the region of the foot, which was flexed with the toes in extension. At the same time the wound from which the foreign bodies had been withdrawn was suppurating profusely, and in the neighbourhood of the wound the inflamed lymphatic network could be seen descending toward the thigh.

The patient, interrogated as to the exact period when what he called his "cramps" commenced, admitted to us that he had had them for four days; that they commenced in the foot, and gradually extended to the whole lower leg, but knowing that there was a question of evacuating him he did his utmost to prevent anyone discovering this when dressing his wound.

We immediately administered a fresh injection of anti-tetanic serum, 20 c.c. In addition to this two injections of carbolic acid, 20 c.c. of a 1 per cent. solution were given morning and evening. At the same time we prescribed two doses of chloral per rectum (4 grammes) in the 24 hours.

On the following day, the 24th, the quantity of carbolic acid solution was increased to 80 c.c. per diem, given in two doses, and was continued thus for seven consecutive days, then diminished to 50 c.c. for the four following days. The chloral was continued at the rate of 8 grammes per diem the whole time (11 days).

On the 24th the entire lower limb was in a state of contracture, in forced extension; foot, lower leg, and thigh formed a whole rigid as a bar of iron, which seemed welded to the pelvis.

At the same time the wounded man complained of violent pains in the form of troublesome cramps.

On the 25th the spasm began to diminish; raising the thigh in one hand and pressing the other hand on the lower

leg, one could now cause a slight, very slight flexure of the knee, barely amounting to two or three degrees.

On the 26th the patient suffered less acutely; with a great deal of effort he managed to lift his knee slightly from the plane of the bed, and he himself repeated the very slight flexion produced by us the day before. On the following days the improvement continued. On the 4th May, for example, M—— was flexing the lower leg freely upon the thigh, and with more difficulty the thigh upon the pelvis. As for the foot, it was still forcibly flexed, the toes drawn up by the extensors, whose tendons had the appearance of stretched cords on the dorsum of the foot. Nevertheless, a few slight movements of the toes were seen to occur.

On the 14th May—that is, about a month after the wound—twenty-four days after the first signs of tetanus, the patient had completely recovered from this complication. His wound was advancing favourably toward cicatrisation.

This was a case of monoplegic tetanus which appeared about eight days after the wound, in a man who was not injected until forty-eight hours after the wound.

Observation X. (Laval)

André M——, twenty years of age, was wounded at 1 o'clock in the morning of the 18th October, at Éparges, by a grenade.

Dressed half-an-hour later at the field ambulance; second dressing, with operation, at the M—— hospital, at 11 o'clock.

Antitetanic serum a few hours later.

On arriving in hospital on the morning of the 21st October the presence of two wounds was noted. One, a hand's-breadth in width, occupying the whole of the right-hand thoraco-abdominal region, appeared superficial. The other, in the retro-trochanterian region on the same side, was penetrating; the splinter which caused it was said to have been extracted on the 18th. One could still see the trace of the incision made on the antero-external face of the thigh, about four inches from the orifice of entry.

The treatment consisted of cleaning the thoraco-abdominal wound with hydrogen peroxide, and applying a dressing moistened with Javal's solution, 4 per cent. The wound on the hip, which exhibited no inflammatory reaction, was dressed with the same solution.

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The dressing was performed regularly every day, when on the 24th October—that is, six days after the wound—M— suddenly complained of pain in the right ankle.

Very disturbed night.

27th October.—The pains increased and assumed the form of cramps, which made the patient cry. Morphia was given.

At 2 P.M. the thigh and lower leg were the seat of horribly painful spasmodic contractions. During the spasm the limb would violently extend, as though under the impulse of a stretched spring, and toes, foot, lower leg, and thigh formed a rigid whole. During this tonic convulsion the patient literally roared with pain, this lasting 25 to 30 seconds; then a remission occurred. The limb resumed its normal aspect, but at the end of a few seconds the convulsion reappeared.

These were evidently tetanic convulsions.

Treatment.—1. Antitetanic serum, 20 c.c.

2. Injection of dilute carbolic, 1 in 100, 20 c.c. night and morning.

3. Chloral, per rectum, 3 grammes whenever the patient began once more to complain of the pain.

In consideration of the severity of the case, we

1. Injected 160 c.c. of antitetanic serum, at the rate of 20 c.c. per diem, until the 31st October, except on the 29th and 30th, when we injected 30 c.c. each time.

2. The injections of carbolic acid were increased from 40 c.c. to 80 c.c. daily, and were then decreased to 40 c.c.; they were not discontinued until the 8th November. Very well tolerated.

3. The average amount of chloral given per rectum was 13 grammes in the 24 hours, except for three days, when we were obliged, in order to quiet the patient, to go up to 18 grammes. This medicament was discontinued on the 8th November, simultaneously with the carbolic acid injections.

8th November.—All spasms had ceased; the malady would be regarded as arrested. The spasms had never extended beyond the right lower limb. For three days the pelvic muscles participated in the rigidity, but the latter never mounted higher, nor did it reach the lower limb on the other side.

Observation XI. (Carnot).—Local and late-appearing tetanus

A soldier was wounded in the left arm by a shell-splinter on the 16th June 1915, and evacuated after an injection of 10 c.c. of antitetanic serum.

The wound healed in a fortnight; nevertheless, on the thirtieth day a small blister appeared in the region of the wound, with a drop of pus in it.

From this time the patient felt, at short intervals, slight pains in the wounded arm, but these did not seem to be of any great importance. The patient was therefore allowed out, and then, on the 6th August, sent to his depot. On his return the arm had become painful and its contracture prevented extension; he was exempted from service for a week. Finally, the tetanic phenomena being very plainly defined, he was sent to the hospital for contagious diseases at Épinal, on the 19th August 1915, or more than two months after the initial wound and the preventive antitetanic injection.

On his arrival the patient exhibited a permanent local contracture of the left upper limb, with tetanic spasms. The contracted arm was pressed against the thorax, the forearm flexed and supported by the sound hand.

Occasionally it would be thrown suddenly forward by a painful spasm lasting some seconds. This spasm was repeated several times per minute; it was excited by the slightest sound, or an emotion would cause it.

Although the tetanus was almost entirely localised to the wounded limb, a slight stiffness was observed in the back of the neck, a slight strabismus, and a few rare cramps in the right arm and the legs.

No trismus: no difficulty of deglutition; no dyspnoea; no spasms of the respiratory muscles.

The wound, situated on the anterior face of the upper arm, a few fingers'-breadth from the bend of the elbow, was entirely cicatrised; it appeared neither red nor oedematous, and there was no discharge from it. The temperature was $101\cdot3^{\circ}$ F.

Immediately after the patient's arrival an intravenous injection of 40 c.c. of antitetanic serum was administered, but as the subject had already been given 10 c.c. of serum two months earlier the possibility of anaphylactic accidents

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was feared, and Besredka's method of administering very small initial doses was practised.

On the following day, the 20th August, little modification ; the tetanic paroxysms were intense, localised almost wholly in the left arm.

On account of the local character of the contracture (and also of the slightly abnormal strabismus) the nervous condition of the subject was examined, and the cerebro-spinal fluid was drawn off; it was normal. Advantage was taken of the lumbar puncture to administer an intra-rachidian injection of 20 c.c. of serum ; there was no anaphylactic reaction. The tetanic cramps, far from diminishing, increased in violence and intensity.

The temperature was 101·6° F.

Two days later it was decided to explore the seat of the old wound, in search of pus or a foreign body which might explain the deposition and late revivescence of tetanic spores.

The incision was made right through the cicatricial tissue, but neither pus nor fragments of clothing were discovered ; the only slightly abnormal fact was a discontinuity of the tissues which made it possible to introduce a grooved probe to a depth of 2½ inches, but there was no oozing. Nevertheless, an injection of 10 c.c. of antitetanic serum was made in the region of the wound.

On the other hand, a series of deep injections of serum (30 c.c.) was made along the course of the nerves, on the internal face of the biceps, towards the armpit, or in all an interstitial injection of 40 c.c. of antitetanic serum.

A slight improvement was visible as regards the intensity of the crises, but this was due chiefly to the chloral (6 grammes daily).

The temperature fell, and on the 22nd was only 99·7° F. in the morning, and 100·2° F. at night.

On the 22nd an intravenous injection of 40 c.c. of anti-tetanic serum was administered.

On the 23rd an intravenous injection of 20 c.c.

The improvement continued, but without accentuation, and the tetanic cramps still persisted, although a little less violent. The chloral was continued.

By this date the patient had in all received, in addition to the 10 c.c. of the preventive injection, and without any

anaphylactic accident, 160 c.c. by intravenous injection, 20 c.c. by intra-rachidian injection, and 40 c.c. by interstitial and paranervous injections.

On the 26th the temperature was tending to rise, and in the morning was 100·4° F. The tetanic contractions appeared to be increasing ; there was once more a slight stiffness of the back of the neck, and a few cramps in the opposite arm and the legs. It was decided once again to inject 20 c.c. of serum by intravenous injection, but hardly had the injection been administered when the patient's expression changed ; he became congested, and he complained of sensations of heat and general malaise. He felt suffocated, became cyanosed, and was conscious of a sensation of extreme anguish, with difficulty in breathing, and retrosternal pain ; at the same time the pulse became thread-like and could not be counted ; an extreme fall of blood pressure manifested itself. In short, an intensely dramatic clinical picture was suddenly manifested—precisely that which has been experimentally observed after the “releasing injection” in cases of anaphylactic shock. After a few agonising minutes the purplish face grew ruddy again, and profuse perspiration appeared on the face and limbs, but exclusively on the non-tetanised side. However, during the whole day the patient remained a prey to extreme anxiety. The pulse was 140 ; the low blood pressure continued, and the situation remained serious.

The tetanic paroxysms had not, however, ceased ; they were both frequent and severe ; they were still predominantly localised in the left arm, but a few occurred in the legs and the right arm. The dysphagia was so great that the patient could not even swallow fluids. The anaphylactic shock seemed, at this moment, to have accentuated the tetanic phenomena.

On the following day, the 27th August, in the morning, and without any further injection, the patient, who appeared for the time being out of danger, was suddenly attacked by symptoms like those of the previous day. The face became cyanosed ; the heart was disordered ; dyspnoea suddenly set in, violent and paroxysmal ; the anxiety became extreme, with a sensation of imminent death ; the pulse could not be counted, the hypotension was considerable, and once again profuse sweats covered the right side, which was not tetanised. Under the influence of injection of ether, caffeine, and

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adrenalin solution the blood pressure increased, and the anaphylactic symptoms once more became attenuated.

Nevertheless, the pulse remained low tension and thread-like and rapid (140) the whole of that day. The temperature was 102·2° F. on the evening of the 27th, and 99·8° F. on the morning of the 28th. The anxiety persisted, with psychical excitement. The tetanic cramps were still exacerbated in the left arm; a few occurring even in the legs and the right arm. There was moderate stiffness of the back of the neck. No trismus; dysphagia highly accentuated.

The anaphylactic symptoms continued, with less violence, for some days, characterised by hypotension, tachycardia (140), and extreme malaise.

The temperature remained high: 103·1°, 103·5°.

Locally the wound had become red, oedematous, and indurated, and so, for that matter, had all the regions in which the serum had been injected, but without necrosis (local anaphylaxis).

Then, rather suddenly, from the fourth day onwards, the temperature fell to 102° F. on the evening of the 30th and 99·8°, 99·3° F. on the 31st.

The pulse fell from 140 to 112 per minute. The anxiety was considerably alleviated; confidence returned. The tetanic cramps themselves diminished in intensity and frequency (only 12 in the 24 hours), but there was still, in particular, a permanent plastic contracture of the forearm upon the upper arm.

The dysphagia had disappeared; the patient was drinking, and his appetite was returning.

In short, five days after the anaphylactic shock a true critical period supervened, with rapid amelioration of all the symptoms—not only the anaphylactic symptoms, but the tetanic symptoms also, and with a general return to the normal state.

From this moment the tetanic paroxysms diminished progressively. The permanent contracture persisted for some time longer, with reflex hyper-excitability. The subject remained all day with the left forearm flexed upon the upper arm, the upper arm pressed against the thorax, the sound hand supporting the left arm to avoid positions of extreme contraction.

For hours he remained with a weight suspended to the

affected limb, in order to effect its extension progressively and slowly. There were no further painful cramps. The patient gradually recovered strength. He left, convalescent, on the 15th October, still retaining a slight contracture (in flexion) of the left upper limb, which did not prevent its employment.

Observation XII. (Rauzier and Estor in a thesis by Señor Ramirez).—Montpellier, July, 1915. Late-appearing tetanus localised in the lower limb

L——, twenty-two years of age, was wounded on the 17th January 1915. Slight wound in the right foot, with small fragment of shell enclosed, and a second very superficial wound of the lower leg. The shell-splinter was removed and an injection of serum given immediately after the wound. Intervention in the region of the cicatrix on the foot, after radiography, on account of recent pains and spasms (21st April 1915). No other projectiles.

Since the operation, persistence and recrudescence of the painful contractures in the region of the wounded limb.

This, at the moment of the spasm, became hard as wood along its whole length, and absolutely rigid. On inspection one could see the contracted masses of muscle in prominent relief. The spasms were accompanied by very violent pains, forcing cries from the patient. They were awakened by the slightest touch, an exploration of any kind, or the least excitation of the senses (a noise, etc.). Nothing in the region of the arms, excepting an occasional and transient stiffness of the right arm.

A few contractions of the face were noted, but no trismus, no cervical contracture, and no dyspnoea.

The temperature never exceeded 99.3° F.

The patient was treated with serum, carbolic acid, and large doses of chloral. No respiratory or digestive disorders.

Examination.—Complete rigidity of the lower limbs, above all of the right lower limb, provoking a veritable appearance of ankylosis at moments, and diminishing at intervals.

Nothing in the region of the upper limbs, face, neck, or throat.

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The patient could not sit down. General hyperæsthesia was noted on giving injections.

The reflexes appeared to be abolished, and there was no Babinski's sign; the pupils were normal.

The intelligence was maintained, but greatly depressed.

On pressure in the region of the left iliac fossa, a marked feeling of strangulation was noted.

No indications in chest or heart.

Urine normal.

Chloral from the 30th April to the 12th May, at the rate of 10 grammes in the 24 hours.

This was progressively diminished until the 16th May.

Antitetanic injections commenced the 4th May, finished the 14th May.

Injections of carbolic acid commenced the 4th May, discontinued the 19th May. The affected leg gradually became flexed after the 14th, and was finally folded right back; it was only after the lapse of some days that it began to straighten itself again. Stiffness ceased on the 19th May.

Observation XIII. (M. Henri Bouquet)

H—— (Georges), of the 1905 class, discharged for endocarditis on the 8th July 1908, was re-enlisted at his own request on the 8th August 1914. Appointed to the 26th Battalion of Chasseurs à Pied.

Wounded on the 6th September 1914, at noon, during the attack on the Abbaye Wood, near Saint-André (Meuse), where he was acting as a sniper. Remained in this wood with several comrades grievously wounded, like himself, until the 10th September, feeding on blackberries and drinking rain-water caught in the hollows of leaves. He had five wounds: (a) an extensive wound caused by a shell-splinter, involving the posterior external portion of the left lower leg with fracture of the fibula; (b) a wound caused by a shell-splinter, very deep, in the middle portion of the left thigh; (c) a penetrating wound caused by a bullet, in the left forearm; (d) a penetrating bullet-wound in the right ankle; (e) a penetrating bullet-wound above the left external malleolus. He was also suffering from dysentery.

Picked up by the Germans, on the 10th September, at

6 in the afternoon, and taken by them to the hospital at Saint-André, the first dressings were applied there. Left behind when the enemy retreated, on the evening of the 12th September, he was carried into the French lines on the 13th, owing to the care of a French surgeon, a prisoner like himself. The second dressings were applied on the 14th September, at the Rambluzin field hospital. Taken to the Radeport railway station, and placed in an ambulance train, he reached the Bar-sur-Aube hospital at 10 o'clock at night. There an injection of antitetanic serum was administered the same night.

He was treated at the Bar-sur-Aube hospital from the 15th September to the 18th December. He left it almost cured, one of his wounds still requiring attention, while the dysentery was only ameliorated; he walked with difficulty. For these various reasons he entered Auxiliary Hospital 102, 18 rue Charles-Oivry, Paris, where I attended him.

He told me that six weeks after entering the Bar-sur-Aube hospital he was afflicted by a difficulty in opening the jaws, with acute pains in the region of the temporo-maxillary articulation. A few days later similar pains appeared in the neck, accompanied by a sensation of "stiffening" (this was the word used by the patient himself) in the muscles of that region. When I saw him for the first time these phenomena had diminished in the temporo-maxillary region. The jaws opened almost normally, but when the man spoke the pains recurred for the moment in the region of the jaws. In the back of the neck the pains and contractures were severe and permanent. From time to time there was an exacerbation of these phenomena, and one could then feel the contracture of the muscles under the hand; they became of a woody hardness. When these paroxysms occurred the patient was obliged to lie down, or at least to seat himself in a reclining chair. The pains frequently descended below the shoulders, along the vertebral column. The paroxysms were most frequent during the night and in bed.

At this stage I diagnosed the affection as late tetanus, but considering that these late forms could not possibly be serious, I instituted no further treatment than sedative frictions with alcohol in the regions affected. The phenomena gradually disappeared. When the patient left the hospital, being

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temporarily discharged from service, he was suffering only from very slight occasional spasms, which occurred at very long intervals. These ceased entirely a short time after he left the hospital. The dysentery yielded to a treatment, which was principally dietetic, only eight or ten days before he left. At the present time the patient is in good condition, although he still has a certain difficulty in walking and an eversion of the left foot, with a tendency to touch the ground only along its outer edge.

Observation XIV. (M. H. Bouquet).—Late-appearing localised tetanus

Louis R——, of the 1st mixed Regiment of Sharpshooters and Zouaves, entered Auxiliary Hospital No. 102 on the 29th October 1915. Wounded on the 6th October 1915 at Ferme-de-Champagne. Having received the preventive injection of antitetanic serum on the 7th October, he was first under treatment in the hospital at Revigny, before entering our sanitary formation.

The wounds were on a fair way to be healed when, on the 19th December 1915, the wounded man was attacked, at intervals of a few hours, by three tetaniform paroxysms. He was suddenly attacked by violent pains in the epigastric region, the head being slightly retroverted. The face was grimacing ; there was, however, no trismus, but if one placed the hand on the abdomen one felt the forcible contracture of the rectus, which was veritably tetanised. The first attack left my diagnosis in abeyance. At the second I suspected delayed tetanus, and administered a subcutaneous injection of 10 c.c. of antitetanic serum. Thereupon, on account of the regulations in force, I was obliged to send my patient to the special department for contagious cases. He was therefore admitted to the hospital in the Lycée Buffon, where we learned recently that the patient had recovered, and that he had been given intravenous injections of antitetanic serum.

Observation XV. (Mériel).—Tetanus localised in the lower limb

Julian L——, of the 342nd Regiment of Infantry, was wounded on the 28th September 1915 at Virginy, by shell-

splinters. The first dressing was applied on the spot, an hour later. The second was applied at the field hospital, where an antitetanic injection was administered.

The patient arrived at Foix (Hospital No. 1) on the 3rd October. He presented a superficial wound of the left frontal region, a perforating wound in the upper third of the left thigh, and another wound of the same nature in the lower third of the left lower leg.

On the 8th October, in the evening, the wounded man began to feel pains in the left lower limb. The wounds had a good appearance. No temperature.

On the 9th October sudden and involuntary contractions were noted in the left lower limb, which were at once exaggerated if the patient was touched. The other limbs were unaffected. No trismus; no stiffness of the neck. Temperature, 100.8° F.; pulse, 102. An agitated night.

On the 10th, the tetaniform symptoms persisting, with a temperature of 100.4° F., an injection of 10 c.c. of antitetanic serum was given.

On the 11th, a fresh injection of antitetanic serum and a dose of 2 grammes of chloral per rectum. The patient was isolated. In the evening the contractions, localised still exclusively in the left leg, returned in paroxysms, which were extremely painful, preventing all sleep, and finally necessitating an injection of morphia.

On the 12th, 13th, 14th, and 15th the condition remained stationary, and an injection of 5 c.c. was repeated daily. The chloral and morphia were also continued.

On the 15th, however, the contractions diminished slightly, but a contracture appeared, particularly accentuated in the muscles of the buttock and the posterior portion of the thigh. The patient also complained of violent pains, and cried out, especially at night. He was accordingly given three doses of chloral per rectum daily, and an injection of morphia about 9 o'clock at night.

During the five following days an attempt was made to discontinue the antitetanic injections, but the contractures and pains became more violent. The injections were therefore resumed on the 21st, and continued daily until the 26th, the dose being 5 c.c. on each occasion.

To break the patient off his daily injection of morphia an attempt was made to replace it by a draught containing

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syrup of morphine. None the less he continued to complain all night; he passed urine in the bed; he was delirious, and his appearance was quite abnormal.

The contractions tended progressively to disappear; but the contracture persisted. Between the 28th October and the 2nd November only one injection of 5 c.c. of antitetanic serum was given every second day.

From the 4th to the 19th of November an injection was given only every third day; from the 22nd November to the 3rd December every fourth day; and from the 3rd December to the 17th every fifth day. At the same time the dose of chloral was gradually diminished: from 15 grammes it was reduced to 5 grammes in the 24 hours; first one, and then two doses were suppressed each day; and on the 20th of December the drug was entirely discontinued.

At the same time the dose of morphia was gradually diminished, until it was discontinued on the 25th December.

The tetanic symptoms localised in the left lower limb became slowly attenuated. The lower leg, which had for a long time remained flexed at right angles to the thigh, gradually extended itself, and the contracture disappeared. The toes, at first contracted like talons, gradually assumed their normal position and movements.

The wounds, which had suppurated abundantly while the tetanic paroxysms were still occurring, were now healed.

At the beginning of January the patient was able to get up and walk, still dragging the leg slightly. The general condition was excellent. At the present moment (20th January) he is restored to health.

There was no hysteria in the patient's antecedents. It should be remarked, however, that there was a certain degree of alcoholism, the patient having been carter to a wholesale wine merchant, and accustomed to drinking 5 litres of wine per diem.

Observation XVI. (Personal)

C—, twenty-eight years of age, a second lieutenant, was wounded in Champagne, at Jonchery, on the 25th September, by splinters of a grenade, which occasioned three wounds in the left thigh. He received his first dressing on the same day, about two hours after the wound, at the field ambulance.

A temporary dressing was applied, after the wounds had been disinfected with tincture of iodine.

The same evening the wounded man was evacuated into the Coppery field hospital, and on the following evening—that is, on the 26th September—about ten o'clock, one of the projectiles was extracted, which was causing violent pain, owing to its superficial position on the internal and posterior region of the thigh, it having traversed the anterior face of the member about the middle portion of Scarpa's triangle.

This projectile was discovered at a depth of about two-fifths of an inch, and, according to the information furnished by the patient, it was about the size of a hazel-nut. The two other wounds were disinfected; one being at the base of Scarpa's triangle, near the outer edge, and about four-fifths of an inch in length, while the other, which was smaller, was on the external face of the thigh, about four-fifths of an inch from the great trochanter.

After the dressing a preventive injection of 10 c.c. of antitetanic serum was given; this was on the day after the wound.

On the 28th September the patient left the hospital at the front and was sent to Paris, where he arrived on the morning of the 29th. He was admitted to Temporary Hospital No. 60.

In this hospital the wounds were dressed daily. A radiographic examination revealed the presence of two large grenade-splinters, about the same size as that which had been extracted, one being situated in the internal and superior portion of the thigh and the other in the superior and external portion.

A little lower the presence of five or six other small splinters was noted. The wounds were suppurating profusely. The pain in the region of the wounds was not very marked. The general condition remained good, and the rectal temperature was normal.

On account of the situation of the projectiles, and also the appearance of muscular contractions, the patient was evacuated, on the 21st October, to the clinic in the Rue Bizet, under the direction of Dr Gosset. There the splinters were localised by means of the Bergonié apparatus, and Dr Gosset thought it best to send the patient to the Hôpital Buffon, on the 23rd October.

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At this date the patient stated that ten days after he was wounded, while he was in Temporary Hospital No. 60, muscular contractions appeared on the inner face of the left knee, which were of short duration (two or three seconds) but extremely painful. They recurred about once in two minutes. These contractions increased day by day, progressively, in severity and in frequency, while at the same time they became more painful. There was no contracture or cramp in any other part of the body, no trismus, and the temperature was normal.

About the fifth day—that is, fifteen days after he was wounded—there was a remission for 24 hours, marked by less violent and less frequent pains and contractions, these recurring only about once in five minutes. The wounded man even felt that he was in a fair way toward recovery. But on the following day the convulsive jerks reappeared, more marked than before, and extremely painful. They were then recurring three or four times a minute, and lasted two or three seconds.

The absence of trismus was still noted, and there was no temperature. The patient was able to take his food normally.

Upon his entering our hospital, on the 21st October, the patient appeared to us to be greatly fatigued and anxious. He complained of having had no sleep since the 5th October. On examining him we were immediately struck by the clonic contractions involving the entire musculature of the wounded thigh. At the same time the patient complained of excruciating pains during the paroxysms. The convulsive jerks were recurring three or four times a minute. There were no longer any remissions, and the contractions were localised in the upper portion of the left thigh. No trismus was observed, nor any contractures or pain in the right leg. But the left lower limb was contractured, the lower leg being lightly flexed upon the thigh and the thigh upon the pelvis.

The temperature was not very high: 99.7° F. in the evening.

A subcutaneous injection of 30 c.c. of antitetanic serum was given this day (21st October).

22nd October.—The patient was still in the same condition, complaining of extremely violent pains. He was greatly agitated.

The contractions remained localised in the left thigh.

The temperature, in the morning, was 98·9° F.; in the evening, 99·7° F.

This day a certain constraint was noted in the temporo-maxillary articulation, although there was not as yet, properly speaking, any trismus.

25th October.—The muscular jerks were still very frequent and very painful. At the same time, a fairly well defined trismus was noted in the morning, rendering alimentation difficult. The wounds were suppurating profusely, and, considering the general condition of the patient, the surgeon's intervention was requested; it was hoped that the nervous symptoms might thereby be arrested.

The temperature was still almost normal: 98·9° F. in the morning, and 99·1° F. in the evening.

Dr Berger operated. After making a vertical incision in the Scarpa's triangle of the left thigh, and having penetrated the cribriform fascia, the surgeon removed a foreign body which was situated inside the sheath of the blood-vessels in contact with the femoral vein.

Dr Berger made a second incision in the superior and external portion of the thigh, penetrating the fascia lata, and removed a foreign body.

A third foreign body was quivering behind the blood-vessels, but was deeply buried; the surgeon decided not to attempt its removal.

An injection of 5 c.c. of antitetanic serum was made in each wound, and another of 10 c.c. in the femoral sheath, over the crural nerve.

Dressing.

An injection of 1 centigramme of morphia was given also, and the patient absorbed 20 grammes of chloral.

24th October.—Morning temperature, 100·7° F.; evening temperature, 102·1° F. Pulse, 100.

Milk diet. Injection of 35 c.c. of serum. Chloral, 20 grammes. Morphia, 2 centigrammes.

The local condition was practically the same as the day before. The convulsive jerks were as frequent, as painful, and of the same duration. Trismus worse.

25th October.—Temperature, 100·7°; pulse, 94. Urine, 400 c.c. Subcutaneous injection of 40 c.c. of serum. Chloral, 15 grammes; morphia, 2 centigrammes. Same condition.

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26th October.—Temperature, 100°. Pulse, 88. Urine, 600 c.c.

An injection of 60 c.c. of serum. Chloral, 12 grammes.

No perceptible amelioration.

27th October.—Temperature, 100·7°, 102·9° F. Pulse, 120. Urine, 200 c.c.

An injection of 40 c.c. of serum. Chloral, 4 grammes. Morphia, 2 centigrammes.

28th October.—Temperature, 104°, 103·6° F. Pulse, 108. Urine, 700 c.c.

Despite a very marked seric reaction, 10 c.c. of serum was injected. Chloral, 6 grammes. Delirium. The muscular contractions still persisted, frequent and extremely painful. On examination no further localisation of the contractures was observed.

29th October.—Temperature, 100·4°, 100·8° F. Pulse, 100, 120. Urine, 200 c.c. Injection of 30 c.c. of antitetanic serum. Chloral, 8 grammes.

30th October.—Temperature, 100·4°, 101·5°. Pulse, 114. Urine, 2000 c.c.

Injection of 20 c.c. of serum. Chloral, 6 grammes.

31st October.—Temperature, 101·1°, 100·4° F. Pulse, 96. Urine, 1500 c.c. Subcutaneous injection of 10 c.c. of serum; chloral, 6 grammes.

1st November.—Temperature, 100·7°, 100° F. Pulse, 112. Urine, 1700 c.c. Injection of 10 c.c. of serum.

2nd November.—Temperature, 99·3°, 98·9° F. Pulse, 92. Urine, 1500 c.c. General condition improved; but the contractions were still very frequent.

3rd November.—Injection of 10 c.c. of serum.

5th November.—Injection of 10 c.c. of serum. Chloral, 3 grammes.

From this date the contractions diminished in frequency and duration, and a progressive improvement was noted day by day, until on the 12th November the convulsive contractions disappeared.

On the 9th November a further injection of 20 c.c. of serum was given, and on the 11th an injection of 10 c.c.

Recovery seemed complete until the 20th November, on which day the patient exhibited a slight rise of temperature and a slight difficulty in mastication, without any further signs of contracture. On the following day, after an in-

jection of 20 c.c. of serum, all became normal once more, and the patient felt extremely well.

The wounds had cicatrised about six days earlier.

1st December.—The patient exhibited merely a functional difficulty in using the left leg. This limb exhibited a persistent stiffness: the movements of the hip-joint were very free, but in the knee, on the other hand, there was an obvious constraint. The movements of flexion were limited. In the tibio-tarsial articulation the derangement was still more marked; the movements of the foot were almost impossible. The leg was in extension. The foot was in external rotation, with a tendency to talipes equinus. There was a very marked retraction of the tendon of Achilles, and a slight muscular atrophy could be noted on the side affected.

Examination of Reflexes.—Percussion of the patellar tendon provoked a tonic contraction of the quadriceps on the affected side.

There was exaggeration of the patellar reflex with clonus of the patella. The Achilles tendon reflex was normal. Babinski's sign was negative. There was no exaggeration of the defensive reflexes, and no indication of spinal lesion.

An examination of the electric reactions revealed a notable diminution of the contractility of the muscles and nerves of the affected limb when stimulated by galvanic and faradaic currents.

In the upper limbs the reflexes were normal. It should be noted that the masseteric reflex was exaggerated.

Here, then, we have a case of early tetanus localised in the left leg.

CHAPTER II

HISTORICAL

ALTHOUGH cases such as those described are excessively rare, it must not, therefore, be supposed that the localised and partial forms of tetanus escaped the attention of the ancients. Hippocrates even, in respect of tetanus, indicated three forms : "straight" tetanus, opisthotonus, and a third more serious form. But Guy de Chauliac, in 1363, was the first to draw the distinction between generalised and localised tetanus.

In 1772 Sauvages described the chronic form of tetanus, which he styled Cathocus, and the lateral form, of which, according to Rose, we find the first indication in Sophocles.

Larrey distinguished acute and chronic, partial and complete tetanus, and recorded examples of localised tetanus.

Dupuytren cited a case of tetanus following upon a contused wound of the thenar eminence ; the wound had healed when the patient experienced extremely severe pains with contracture of all the fingers. Similar observations were placed on record by Rémy, Annandale, Gintrac, Gross, and Heinke.

Colles, in 1852, and Follin, in 1861, distinguished between the true general tetanus and tetanoid spasms confined to the injured member.

Legouet recorded the case of a lad of fifteen who was attacked by localised trismus as the result of an accident

which tore off the third phalange of the forefinger, with its flexor tendon.

In 1870 Richelot recorded the case of a wounded man who was affected by a partial tetanus which lasted for several weeks. Having left hospital too soon, the patient was attacked by generalised convulsions, and succumbed in a few days.

In 1883 Bond observed a cephalic tetanus which set in on the twentieth day, and a similar case was recorded by Buisson in 1888, the period of incubation being twenty-two days.

In 1904 appeared Demontmerot's thesis on the paraplegic form, in which four observations were recorded. Esau, in 1910, published the details of a case of local tetanus of the hand. But as we have already remarked, in the majority of these observations the affection described is not, properly speaking, a true partial tetanus. If by this term we understand an infection by Nicolaïer's bacillus, localised in a determined anatomical region, and not proceeding to generalisation, we may say that the history of partial tetanus of the limbs is of recent date. We have seen how the observations of Esau, Boinet and Monges, and Curtillet and Lombard should be regarded ; and certain observations which were published by Demontmerot in his thesis should likewise be classified as cases of tetanus with paraplegic onset rather than as observations of paraplegic and partial tetanus, for after a transient and initial localisation of the contractures in the lower limbs, trismus appeared, with stiffness of the neck and trunk.

We may therefore consider, in accordance with the definition which we have given of local tetanus—"an affection which is local during its entire development "

—that observations of local tetanus of the limbs, at all events of the monoplegic form, have not long been known.

In May, 1915, appeared the first report of a case of local tetanus of one leg, in a work of Courtellemont's.

Then, in June, 1915, Albert Ramirez Martinez reproduced in his thesis a very instructive observation by Professors Rauzier and Estor. This was of a late-appearing localised tetanus, the seat of which was one of the lower limbs.

Then Pozzi, from the tribune of the Academy of Medicine, in November, 1915, described a typical example of early local tetanus of the limbs. The localisation was in the first place monoplegic, then, temporarily, paraplegic, but with a marked predominance in the wounded leg. It persisted for five weeks, and was followed by recovery.

This observation, the first of this rare clinical type, evoked, by its interest, the publications of Monod, Routier, Laval, Carnot, Courtois-Suffit and René Giroux, and Mériel. Now that these cases are better known, they have become less rare. At the present time numerous cases have been recorded, and Dr Fricker, in connection with a certain number of personal observations, has lately reviewed the question of the partial forms of tetanus in his inaugural thesis.¹

In the following pages we shall describe the peculiar symptoms and the special evolution of this local and atypical form of the tetanus.

¹ Unfortunately we have not been able to consult this thesis; we feel, however, under an obligation to mention it, in order that the reader may consult the observations recorded by this writer.

CHAPTER III

MONOPLEGIC FORM

1. Period of Incubation.—The period of incubation is the interval of time which elapses between the moment of infection and the moment at which the first tetanic symptoms appear. Generally speaking, inoculation with the bacillus gives rise to no immediate sign. No local or general phenomena reveal the multiplication of Nicolaïer's bacilli, nor the progressive invasion of the system by the toxin.

Here we have an *insidious phase*, during which the tetanic infection is developing, although nothing enables us to detect it.

This insidious phase is of very variable duration. It may be brief or prolonged, so that there are two distinct forms of tetanus, distinct, at least, as far as the appearance of the first tetanic manifestations is concerned. These are :

1. Early or precocious local tetanus.
2. Late-appearing local tetanus.

In the first variety the incubation period is in general of brief duration, the first symptoms usually appearing between the fifth and tenth day. This was the case with the observations recorded by Pozzi (fifth day), Laval (eighth and ninth days), and ourselves (tenth day). In this connection, whenever the first signs of tetanus appear during the fortnight following the wound, we regard the disease as being of the early or precocious form.

In the second variety, the late-appearing form of localised tetanus, the period of incubation is always lengthy, sometimes extremely lengthy. This, by the way, is one of the most important characteristics of this form.

Generally speaking, the first clinical indications of the late form of local tetanus appear from twenty to thirty days after the wound, when the latter is becoming cicatrised, or is already completely cicatrised. Sometimes this lapse of time is even greater.

Demontmerot has recorded a case in which the first symptoms did not appear until six weeks after the infliction of the wound. In Rauzier and Estor's case the period of incubation was three months. Finally, it must be mentioned that Huntington has cited a case in which tetanus appeared seven months after the wound, the latter being still discharging. This long incubation in the late-appearing form is often, however, apparent only. Bérard and Lumière have, in fact, demonstrated that this variety often develops as the result of a surgical traumatism, appearing six, eight, ten, or fifteen days after operative intervention, which usually takes the form of a tardy cleaning out, the search for a foreign body, or a secondary amputation, sometimes—indeed, as a rule—involving the region of the wound, and sometimes a region remote from the wound. It seems logical to accept the period which elapses between the surgical traumatism and the appearance of the first signs of confirmed tetanus as constituting the actual period of incubation. The spores have hitherto remained in a condition of latent vitality, enclosed in a crevice which isolates them for the time being, or encysted in a shell of inflammatory tissue. By an exploration or surgical operation of some sort these spores are set free, sowing

themselves in the adjacent tissues and secreting their toxins there. These, therefore, are cases of secondary reinfection, due to tardy surgical intervention.

The development of these late-appearing forms of tetanus permits us to refer them to latent microbial infection due to the mechanical liberation of the spores, analogous to that of postponed infection. This has been demonstrated experimentally by Tarozzi, Canfora, and Vincent, who, after injecting cultures of Nicolaïer's bacillus into the veins, or even under the skin, have found spores in the viscera of the animals experimented upon several weeks after injection. They have shown that a traumatism, or any factor which diminishes the resistance of the organism, as cold, for example, may result in an outbreak of delayed infection.

On other occasions the surgical traumatism does not give rise to tetanus, but accelerates the development of tetanus in incubation. Thus in the cases recorded by Vallette and Leriche tetanus made its appearance thirty-seven and forty-two days after the wound, and only twenty-four to forty-eight hours after operation. This lapse of time is too short to be regarded as a period of incubation.

From these considerations it results that it is often difficult to form an approximate estimate of the period of incubation in the late-appearing forms, but it always exceeds twenty days. This period of at least twenty days should indeed be regarded as the minimum incubation period in the late-appearing forms of localised tetanus.

2. Period of Onset.—Whether the form in question is early or late-appearing, the earliest symptoms are assuredly those which it is most important to under-

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stand, for it is a matter of urgency that an early diagnosis should be established, in order that tetanus patients may be treated from the commencement of the infection.

The first symptoms are often unnoticed if one is not careful to interrogate and examine the patient with the greatest care. If the patient does not complain of them these first indications may be regarded as unimportant by a physician who is not on the watch for them, so that it is important to insist upon the first manifestations of the onset of localised tetanus.

Prodromal signs of a local or general character may be noted.

Local Signs.—In the region of the wound, which may be superficial—this, according to some writers, explaining the benign character of certain cases—we may note an arrest of fleshy vegetation, or of suppuration, or swelling, with redness of the skin and mortification.

More significant, and more constant, are shooting pains in the region of the wound, and spasms in the neighbouring muscles, followed by cramps and jerks or twitchings.

But we must at once observe that such local prodromal phenomena as spasms are exceptional in the late form of localised tetanus, which usually declares itself at a period when the wound is cicatrised, so that it might be described as *cicatricial tetanus*.

The pains most commonly appear in the affected limb, but this is not invariably the case; thus to cite a typical example, in the case recorded in Observation V. the wound was situated in the right-hand posterior scapular region, while the pains and contractures first appeared in the right-hand lower limb.

The patient experiences a slight sensation of contrac-

tion in the affected limb, and pain, presently followed by a sudden and involuntary contraction of certain muscles.

A sudden pain, localised in one limb, *without apparent cause*, is an important indication in a wounded man, and the occurrence of pain should always arouse attention and suggest the possibility of a tetanic outbreak.

The pain in question may be fugitive, giving rise to a sudden movement, or a rheumatismal pain, or there may be stiffness in the wounded limb. In addition to pains in the region of the wound, a slight feeling of fatigue in the jaws is sometimes observed.

This pain is presently followed by contracture in the same region. It must be remembered that local cramps occasionally precede trismus even in the normal and generalised forms of tetanus ; so that in order to establish an early diagnosis the physician should never await the appearance of trismus, which in the localised forms is always transient.

Foreign writers have also insisted upon the occurrence of cramps at the outset in their recent dissertations (1914-1915) upon tetanus.

The essential characteristic of the cramps is that they are caused more particularly by external excitation. A cry uttered in the room, the sudden closing or opening of a door, the sudden switching on of the electric light, the fall of any object, the noisy tread of an orderly, the touch of cold hands—all these incidents may provoke the appearance of cramp.

When the patient himself complains that these contractures result from external excitation, there is no further room for doubt : the patient is certainly suffering from tetanus.

The cramps often attack certain groups of muscles,

and confine themselves to these during the whole course of the malady ; or they may spread over the whole of a limb. The contracture is total or partial, and in this latter case one segment of the limb may escape it. This was the case in two of the observations published by Routier : the hand, in the case of one of his patients, remained free, with a contractured upper arm and forearm ; in the other case the lower leg and thigh were rigid, but the foot remained mobile. In the case observed by the present writers the contractures were strictly localised in the left thigh. It must also be remembered that the initial seat of the contractures, or of the symptomatic pains, may be far removed from the point of inoculation. In certain cases, which are, however, rare, the contracture may occur in the muscles of the jaw, but this symptom is always slight and ephemeral. It amounts merely to a certain difficulty in opening the mouth ; the patient can eat, drink, and speak normally.

It must also be remembered that at the very beginning the patient may exhibit *merely a slight stiffness*, which does not prevent his walking. In certain cases the physician himself discovers this stiffness on the occasion of an examination or a dressing.

As Montais remarks, this slight stiffness may be brought to light by attempts to reduce it, by voluntary movements, or by any local excitation. Palpation reveals, in such cases, hypertonia of the muscles which contract through their whole extent when subjected to any excitation. The muscular contraction thus provoked is normally extensive and prolonged, and perceptible to the patient ; after the lapse of a few days it is only too evident.

The general symptoms, in a case of local tetanus, do

not attract the attention of the clinician, and, above all, are less significant than the pains and cramps.

The general prodromal symptoms are headache, anorexia, yawning, lumbar pains, peculiar sensitiveness to cold, a tendency to perspire, disturbed sleep, dysuria, and constipation.

The rise of temperature is very irregular. This fact has been noted by all those writers who have latterly treated the subject. Sometimes there is a rise of temperature at the outset; sometimes it occurs only after the lapse of two or three days, and we shall see that although the fever sometimes attains 104° F., it is more usual to see the thermometer mark 100.5° to 101.5° F., so that the examination of the temperature does not as a rule furnish information of any value.

The pulse is fairly normal.

On the other hand, the change of expression observed in the patient is an indication which demands our attention. When describing the attenuated and slowly developing forms of tetanus we shall see that Claude and Lhermitte have laid great stress upon the facial aspect of the patient.

In the localised forms one is struck by the expression of anxiety of the countenance during the whole development of the disease; an anxiety which is increased by the dread of sounds and movements, and which disappears the very moment the pains and contractures cease.

Lastly, we shall call attention to the fact that from the very commencement of local tetanus there is observed, in the limb which is the seat of the pains and contractures, a certain nervous irritability which is revealed by an exaggeration of the reflexes, which becomes manifest as the acute phase approaches.

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To sum up. The mode of onset of local tetanus of the limbs is almost always identical. Although there is no appreciable cause, although neither the situation nor the nature of the wound give rise to suspicion, a pain suddenly occurs in one limb, usually the limb neighbouring upon or containing the wound, and then contractures make their appearance, recurring under the stimulus of external excitation. The temperature is not very high, but the patient's facial expression becomes anxious. It is as though he were aware that the tetanus was developing toward an acute stage.

3. Period of Acme.—During the period of acme the signs already described—namely, the pains and contractures—attain their maximum intensity ; and it is during this period that the tetanic infection almost invariably exhibits, in the localised forms, ephemeral phenomena of generalisation. These phenomena, however, cancel none of the characteristics peculiar to the special localisation of the disease. A local disease, it remains local, despite transient trismus, and a trace of stiffness in the neck, despite the respiratory troubles which occur in certain cases.

These localised contractures are the signs which dominate the clinical picture : contractures which are sometimes accompanied by extremely violent pains, which force the patient to cry aloud. They are sometimes slight and tardy, but in the majority of cases they are severe and appear early, constituting a significant indication.

The pains coincide with the spasms. Sometimes they radiate through the whole of the wounded limb, sometimes they remain localised in one segment of the limb. Sometimes they extend even further, invading other

regions : the opposite limb, the other limb on the same side, the abdomen, etc. ; or they may be confined to a determined region. Their essential characteristic is that their severity is intensified by the stimulus of the slightest sound, or a sudden movement in the neighbourhood of the patient's bed.

The *contractures* are intense ; they may, like the pains, become generalised throughout the entire limb, or they may be confined to a single segment ; often enough they ascend as far as the abdominal wall. They may also sometimes invade, in a secondary and ephemeral fashion, the opposite limb, or the other limb on the same side. They may constitute the only symptoms of partial tetanus, and in any case they constitute its primary element. They may be divided into two individual types.

They may consist of extremely painful convulsive jerks, which are characterised by clonic movements. These usually occur in paroxysms, which, infrequent or only of moderate frequency at first, become more and more frequent as the malady develops. In our own observation, for example, the clonic contractions in the thigh recurred three or four times per minute ; in the case observed by Pozzi the whole of the wounded leg was every ten seconds the seat of painful contractions of the most afflicting character, until finally the convulsive jerks no longer exhibited any remission, so that the wounded limb remained wholly contractured, the lower leg being slightly flexed upon the thigh and the thigh upon the pelvis.

In other cases (of which examples are recorded in an observation of Routier's, and one of Laval's) these convulsive jerks are not observed, but contractures appear which are persistent from the outset, so that the

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limb, on palpation, feels like a *block of wood*. As a rule there is an excessively painful contracture of an entire limb ; in a case of Routier's the thigh was flexed upon the pelvis, and the lower leg upon the thigh ; the toes were strongly flexed, and all the muscles were rigid. In Laval's case the contracture, which commenced in the foot, gradually gaining the lower leg, had by the following day invaded the whole limb, which, as a result of the generalised contracture, was in a position of forced extension : the foot, the lower leg, and thigh formed a whole, rigid as a *bar of iron*, which seemed welded to the pelvis.

We see, then, that the contractures may reveal themselves, clinically, by clonic movements recurring in paroxysms of varying frequency, or by a generalised tonic contracture, which gives the limb a very characteristic appearance. Contracture in extension, the usual type of contractures of the lower limb, is the rule ; contracture in flexion is a rarer type.

We have mentioned that it is during this period of acme that the traces of generalisation may make their appearance, enabling us with certainty to establish a diagnosis of tetanus. It must not be forgotten—and we wish to lay stress upon this point—that these signs are ephemeral, are not very marked, and are sometimes absent.

In some cases the patient complains of a pain situated in front of the ears, with difficult and painful movements of deglutition. This phenomenon, which in the classic forms of tetanus usually marks the commencement of the period of acme, is here of secondary importance, and as a rule disappears within twenty-four or twenty-eight hours. The pain, moreover, is quite moderate.

Stiffness of the back of the neck is more frequent ; the transient contracture is not very marked. The forward flexion of the head and neck is painful for a few days, at the time when the localised tetanic contractures of the wounded limb reach their maximum. The contracture is never accompanied by the retroversion of the head.

The muscles of the face are in general little affected, and the *risus sardonicus* is never observed.

The muscles of the trunk are usually unaffected ; opisthotonus, emprosthotonus, and pleurothotonos are never observed.

Routier, on the other hand, has mentioned, as an important symptom in localised tetanus, *a more or less marked contracture of the muscles of the abdominal wall*. We must not attach to this sign the importance attributed to it by Bérard and Lumière, in respect to the gravity of the prognosis. These writers regard it as the precursor of contracture of the respiratory muscles and asphyxia ; but in many cases in which this abdominal contracture has occurred recovery has followed.

General Indications.—General indications have not the same value here as in the classical form of tetanus. For example, the *rise of temperature* is very irregular. Sometimes it rises at the outset, sometimes only two or three days later, and while it sometimes attains 104° F., it is more usual to see the thermometer oscillate between 100·5° and 101·5° F. However, the thermal curve is usually ascendant from the commencement of the pains, remaining high until their disappearance.

In the usual form of tetanus the temperature is a great help to prognosis ; if the temperature is very high the case is very serious ; if the temperature is moderate

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the tetanus will be a chronic, less serious form, from which recovery is possible. In localised tetanus the indication derived from an examination of the temperature is no longer of value. Thus in the two fatal cases recorded by Routier the temperature never rose above $102\cdot2^{\circ}$ F.

The pulse is accelerated, but remains regular. The rate varies, as a rule, from 100 to 120 per minute, but one never observes the extreme rapidity, nor the feebleness, nor the irregularities which are noted in the normal forms of generalised tetanus.

We may add, also, that the urine diminishes in quantity, that retention of urine may occur, and that the face becomes covered with sweat at the moment of the convulsive paroxysms.

The facial aspect of the patient, on which we insisted when speaking of the period of onset, becomes still more characteristic. The patient is extremely anxious, even during the periods of calm, and his face assumes a curious expression, which strikes the observer at the first examination. We shall see that this peculiar facial aspect is plainly defined in the attenuated forms of the disease.

The pulmonary disorders are not very marked, the acceleration of the respiratory movements is slight, and, although in the ordinary form of tetanus the contrary is the case, the respiration never becomes dyspnoëic ; it is never more than slightly embarrassed.

Let us note that the patient, as in the generalised forms of the tetanic infection, always exhibits photophobia and a terror of noise and movement, which are due to the hypersensitiveness of the organs of the senses. Lastly, the intelligence, even in the midst of the painful paroxysms, always remains unaffected.

Examination of Reflexes.—*Examination of the reflexes* in local tetanus reveals a constant exaggeration of the osseous and tendinous reflexes, with ankle and patellar clonus. Percussion of the zygoma causes, in certain patients, a sudden extensor movement of the head. The masseteric reflex may be exaggerated ; it was so in the case observed by the present writer.

This exaltation of the osseous and tendinous reflexes is associated with a hyper-excitability of the muscles and nerves to galvanism and faradaism. This sign is observed also in the attenuated forms of tetanus described by Claude and Lhermitte. It must be remembered, however, that the exaggeration of the reflexes may be accompanied, as in the case observed by the present writers, with hypo-excitability of the nerves to electric stimulation.

In localised tetanus, as in the generalised form, the blood exhibits no special reaction. The hæmatological formula depends upon the condition of the initial wound and the presence or absence of septicæmia or anaemia.

It is the same with the cerebro-spinal fluid, which reveals no appreciable modification ; there is no cellular reaction, no increase of albumin. The liquid yielded by a lumbar puncture is sterile and non-toxic.

To sum up. The period of acme in local tetanus, whether early or postponed, is characterised by :

1. Contractures confined to one limb, with more or less frequent spasmoid paroxysms, without lasting phenomena of generalisation.
2. No very noticeable general signs ; the temperature is not high ; the pulse is regular, not exceeding 120, and the respiration is but slightly embarrassed.
3. An exaggeration of the reflexes.

4. A chronic development and a tendency toward recovery in the majority of cases, as we shall presently see when considering the progress and the prognosis of the various forms of local tetanus of the limbs.

Diagnosis

Positive Diagnosis.—While the diagnosis of generalised tetanus presents no difficulty; while trismus, opisthotonus, and the clonic contractions of the whole body form a symptom complex easily recognised, matters are otherwise in the partial forms of tetanus, at all events in the beginning. We must suspect a localisation of tetanus when, the wound being still uncicatrised, or well on the way to cicatrisation, the wounded limb sooner or later becomes the seat of pains or cramps which must be regarded as the first manifestations of contractures. Above all, the diagnosis must incline toward the tetanic infection when the pains and contractures are influenced, awakened, and intensified by sounds or movements or lights. In such a case one may affirm with practical certainty, even if the patient received a preventive injection of 10 c.c. of antitetanic serum within a few hours of being wounded, that he is suffering from tetanus.

Nevertheless, it must not be supposed that hesitation is impossible; on the appearance of the first contractures it is often difficult to form a decision, for which reason we would gladly appeal to the laboratory for the certain information which clinical science is unable to yield. Unfortunately, as we shall see, there is no sero-diagnosis of tetanus by the agglutination test (Courmont). Proceeding from this fact, certain writers have recommended a direct search for the

presence of Nicolaïer's bacillus in the wound. But the bacteriological examination of the secretions of a wound often yielding results of too uncertain a nature, many clinicians are of opinion that experiments upon animals are greatly superior to morphological examination, or culture, for the purpose of determining whether the tetanic bacillus does or does not exist in the wound. Jacobsthal even writes that this is the ideal method, although such experiments occasionally fail. This failure may be attributed to the degeneration of anærobic germs resulting from a mixed infection.

In the early stage of tetanus, accordingly, the laboratory is of no value as an auxiliary to clinical science, and it is greatly to be regretted, from the therapeutic point of view, that the presence of the toxin in the patient's blood cannot be determined before the first symptoms make their appearance.

M'Clintock and Hutchinson, however, were able to prove the presence of the toxin in the blood of sheep which had been infected with tetanus four days before the appearance of the clinical indications.

Differential Diagnosis.—Under these conditions it will be understood that right at the outset, particularly in the late-appearing localised forms, a certain number of affections may give rise to confusion, more or less faithfully simulating partial tetanus.

1. *A spasmotic monoplegia of cerebral or medullary origin* may be characterised by cerebral disorders (ictus, dysarthria, vertigo, headache, sphincter trouble, and modifications of the tendinous reflexes). There is no trismus, and no painful and spasmotic intensification of the phenomena, and the development is not rapid. It is easy to differentiate tetanic paroxysms from the paroxysms of Jacksonian epilepsy, and from

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the syndrome described by Kojenikov, under the name of continuous partial epilepsy.

2. The same is true of *incomplete hemiplegia* with predominance of the signs in one limb.

3. The syndrome of *excitation or irritation of the motor nerves and the mixed nerves*, which may reveal itself, apart from the pains, by the exaggeration of the tendinous reflexes and by contracture, is more difficult to distinguish from partial tetanus. The examples recorded by Le Fort, Dupré, Schœffer, and Le Fur are particularly instructive in this connection.

René Le Fort, in a work entitled *Pseudo-Tetanic Symptoms in Wounded Men suffering from Lesions of the Nerves complicated by the Presence of Foreign Bodies*, refers to the clinical history of three patients, who, having been previously given a preventive injection of antitetanic serum, exhibited painful and spasmoid symptoms in the wounded limb, with contracture in hyper-extension in one case, and in hyperflexion in the other two cases. These symptoms disappeared after the removal of foreign bodies which were in contact with the nerves. The hypothesis of partial tetanus cannot be rejected with certainty, at all events in one of these cases, for the contracture invaded the unwounded limb, and the symptoms at one time assumed a serious character which was not consistent with a simple nervous lesion.

The observation published by Dupré, Schœffer, and Le Fur dealt with a patient wounded on the 20th September 1914, who had not received a preventive injection, and who was attacked, a week after the traumatism, by a serious and acute form of tetanus, which terminated in recovery. The right leg remained flexed, and an operation was performed on the sciatic

nerve on the 7th January 1915. In June the limb still presented tetanic spasms, occurring, in particular, on walking, and remaining refractory to all treatment. Dupré, Schœffer, and Le Fur discuss the possibility of a psycho-neurosis, or of a chronic tetanus. While the hypothesis of a psycho-neurosis is hardly probable, that of tetanus is more so ; but we may ask ourselves whether the lesion of the sciatic nerve was not the origin of the tetanic spasms. However, the existence of a previous attack of acute tetanus, and the character of the spasms, which were not localised in the wounded limb, but were generalised, sometimes invading the masseters, argue in favour of chronic tetanus. It may also be the case that the lesion of the sciatic nerve favoured the persistence of the spasms after the development of acute tetanus, and determined their predominance in the wounded limb. This is a complex problem, and one difficult of solution. A nervous lesion may not only simulate a local form of tetanus, but may also favour its development. It will be understood, in short, that a slight wound of a nerve might localise the action of the tetanic toxin along its course, but we may also conceive that a nervous lesion anterior to tetanus might favour the appearance of the latter. The observation published by Phelip and Policard shows this determining influence ; it deals with a subacute and benign case of tetanus, which, in spite of two preventive injections, developed seventeen days after an excoriation of the hand ; the wounded limb, which was the initial seat of the tetanic signs, had several years previously been attacked by a traumatic neuritis of the median nerve.

4. The contractures or pseudo-contractures following upon lesions of the bones, the joints, the tendons, or

the muscles, are differentiated by their stability and the fixed position imposed upon the limb, while a careful examination of the region involved will always enable the physician quickly to discover the cause of the contractures.

5. *In tetany* we find contractures of the muscles of the extremities, which may extend to the limbs, occurring in paroxysms of very variable duration. The onset may occur unheralded, or may be preceded by prodromal symptoms consisting of disorders of sensibility, formication, numbness of the hands and fingers, and muscular stiffness, and of general disorders: general malaise, cephalalgia, and fever. The contracture is the capital sign of tetany.

The contractures involve, simultaneously or alternately, the upper and lower extremities; they are sometimes confined to one pair of extremities only, usually the upper. The contracted muscles are hard, and raise the skin like tightly stretched cords. It is usually fairly easy to reduce the contracture and restore the members to their normal attitude, but the deformation reappears directly they are released.

The pains, which are spontaneous and moderate, occur in the affected muscles, and along the nerves of the limb, sometimes irradiating over the trunk.

These contractures, as we have remarked, occur in paroxysms lasting five, ten, or fifteen minutes, occasionally one, two, or three hours. The reappearance of the sensation of formication announces the termination of the paroxysms. After a period of repose the fit recurs, and the series of fits constitutes the attack, which may last for some days, or may persist even for one, two, or three months.

Three forms of tetany may be distinguished : a benign form, a form of medium severity, and a grave form. It is more particularly the benign form, in which the contracture may involve a single member, which may be confounded with localised tetanus on a superficial examination.

Examination of the mechanical and electrical excitability of the muscles reveals the existence of several signs which are almost pathognomonic. These are Troussseau's sign, Weiss's sign, and Chvostek's sign, or the sign of the facial nerve.

Troussseau's Sign.—At any time before the termination of the malady one may cause the fits to recur at will, even though none have occurred for one, two, or three days, or more. This is effected, says Troussseau, by exerting compression on the affected member, either upon the course of the principal nerves, or upon the blood-vessels. Thus, by exerting pressure on the median nerve of the arm, or the brachial plexus above the clavicle, the contracture occurs immediately. In the lower limb, if the femoral artery or the sciatic nerve be compressed, or a ligature applied to the thigh, the muscular spasms recur in the lower extremities, although less readily.

Weiss's Sign.—The percussion of the temporo-facial branch at the outer angle of the orbit may provoke a contraction of the orbital, frontal, and superciliary muscles.

Chvostek's Sign, or the sign of the facial nerve, reveals neuro-muscular hyper-excitability of the face. Slight percussion of the facial nerve in the cheek causes a

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sudden contraction, "like a flash of lightning," of the muscles innervated by the facial nerve.

Another sign has been described, which is obtained by raising and forcibly flexing the lower limbs, maintained in extension, upon the trunk; a prompt contraction of the muscles of the legs is produced, placing the foot in forced inversion.

In tetany we find also hyper-excitability of the muscles and nerves to galvanism. The reflexes are maintained, and often exalted, and one occasionally notes vasomotor and trophic disorders. In addition to these signs there is, lastly, a special etiology which determines the diagnosis. It is at present supposed that tetany is caused by an intoxication which acts upon certain elements of the nervous system, and is itself caused by digestive troubles or by a special glandular insufficiency (the parathyroid theory). Recent investigations, indeed, permit us to suspect, in cases of tetany of gastric origin, a parathyroidal insufficiency, and the toxic disorders resulting therefrom. We know, since the publication of the results of Gley's investigations, that ablation of the parathyroids sometimes gives rise in man and in certain animals to grave tetanic symptoms which are often fatal (the tetany of operative myxœdema).

6. *Acute strychnine poisoning* might possibly cause confusion. It greatly resembles tetanus, especially at the outset, for at this period the contractures caused by strychnine affect only the muscles of the lower limbs, becoming generalised subsequently.

The intoxication is preceded by yawning and retinal hyperæsthesia. The pupils are dilated, and objects appear green to the eye. There is often delirium from

the outset, while in tetanus the intelligence is usually unaffected.

7. *Hysterical contractures* may also simulate tetanic contractures, the more so as they may be partial, occupying a group of muscles, a segment of a limb, or a whole limb.

The contracture appears after a convulsive attack, or more rarely without appreciable cause, when it may be the first manifestation of neurosis (Babinski).

Its onset is sudden and rapid, and it attains its maximum intensity at once, or very quickly. The rigidity may be extreme, and very difficult to overcome, causing excessive deformation. Hysterical contractures are usually accompanied by objective disorders of the sensibility : anaesthesia, or hyperaesthesia, whose topography is regional, often being confined to the territory occupied by the contracture.

Its duration is extremely variable. It may persist for a few days or a few months. It may disappear as it came—that is, suddenly, after an attack, or as a result of suggestive treatment.

It may also disappear slowly, little by little. It ceases temporarily, and sometimes finally, under chloroform. Its differential diagnosis is readily established by the fact that the reflexes are not modified (Babinski); there are no spasmotic and painful intensifications, and there is no trismus.

Everything being considered, the establishment of the diagnosis of localised tetanus is, at the outset, a very delicate matter, but the affections which may cause confusion, in particular tetany, the syndrome of excitation of the motor nerves, hysterical contractures, and acute strychnine poisoning, possess a sufficiency of peculiar and characteristic signs to make it possible,

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in the majority of cases, to diagnose them promptly. Moreover, the evolution of the disease furnishes data which assist us to recognise the nature of the contractures, and to show that we have to deal with a localised tetanic infection.

CHAPTER IV

PARAPLEGIC FORM

THIS form of the tetanic infection, localising itself in two symmetrical members, was particularly considered by Demontmerot in his inaugural thesis in 1904. But certain of the cases recorded by this writer do not come under the heading of partial tetanus, for after a first ephemeral localisation in the two lower limbs trismus and stiffness of the neck and the trunk set in. These were therefore cases of classic tetanus with paraplegic onset.

It must be remembered, also, that hybrid forms may occur, intermediate between the monoplegic and paraplegic types. The one type shows itself for a few days only, disappearing and leaving no traces. Pozzi's observation is the first published record of this clinical variety. It describes a localised tetanus with the monoplegic type predominant, the opposite lower limb being affected for a few days, during which period it assumed the paraplegic type.

However this may be, the paraplegic form of local tetanus may assume two clinical aspects, accordingly as the localisation is in the upper or the lower limbs. These are : (1) the superior paraplegic type ; (2) the inferior paraplegic type.

Symptomatology

The signs of the onset, whichever form of the malady is in question, are identical with those observed in

monoplegic tetanus. In this connection we refer the reader to the local and general modifications mentioned in the preceding chapter.

It must be remembered that in this variety it is principally the late-appearing form which is encountered; the period of incubation is almost invariably long: a fortnight, three weeks, or more.

(a) *Inferior Paraplegic Type*.—The inferior paraplegic type is by far the most frequent. The lower limbs are the seat of convulsive jerks of incredible frequency, still further exaggerated by the slightest emotion, the slightest agitation, the least shock or vibration.

In the period of acme paroxysms with remissions are observed. The attitude of the members has been well described by Demontmerot. The limbs, he states, are in forced extension, the foot strongly depressed, the instep salient, the toes usually turned under. Altogether, the foot reproduces with a fair degree of exactness the attitude of talipes equinus.

The muscles of the calf are stretched to the maximum, giving on palpation the sensation of an extremely hard, solid cord. The lower leg itself is extended to the maximum, the patella firmly immobilised, while the thigh is in extension upon the pelvis.

In most cases the contracture invades, at least, the lower abdominal muscles, so that the belly is enclosed by a hard, unyielding wall. Despite the importance which Bérard and Lumière are inclined to attribute to it, we have seen what prognostic value should be attached to this sign in connection with the monoplegic form. No amount of effort will restore the movements of flexion to the various segments of the limb, but the entire lower limb, fixed in extension,

may readily be lifted in one piece, as it were, by the toes.

This muscular rigidity becomes accentuated very rapidly, so that, apart from any convulsive paroxysm, and after the paroxysms themselves have disappeared, the lower limbs are absolutely immobile.

When this form is unmixed, leaving the patient the free use of the upper limbs, the superior vertebral articulations, and the muscles of the face, it gives the patient an appearance which is completely characteristic.

It seems as though the lower half of the body has suddenly been transformed into a lifeless mass, so that one has before one's eyes one of those fantastic mythological beings created by the Oriental imagination, the upper half of whom, being mobile and alive, offers a striking contrast to the lower half, which is immobile, and, as it were, petrified.

(b) *Superior Paraplegic Form.*—In the superior paraplegic form, of which only one case is known (Demontmerot), the upper arms, forearms, wrists, and hands were in forced flexion. The phalanges were folded down upon the palm of the hand, the thumb inserted inside the phalange of the forefinger, and strongly compressed by it ; the distorted hand was drawn violently down toward the forearm by the flexion of the wrist ; the forearm, which was stiff, with the integuments raised by the tendinous cord of the flexor muscles, made a very acute angle with the upper arm ; lastly, the upper arm was closely pressed against the thorax.

This position, carried to its extreme during paroxysms, presently persisted apart from these and, as in the inferior form, prohibited any use of the limbs.

In both types the development of paroxysms causes violent pain in the members affected.

The reflexes remain normal ; Demontmerot observed neither clonus nor exaggeration of the reflexes. The sensibility is normal.

Lastly, the general signs are not marked ; there is only a slight elevation of temperature, the thermometer varying between 98.6° and 100.4° F. ; but this slight temperature quickly disappears once the paroxysm is terminated. This comparative athermia constitutes, as we shall see, another sign of a benign development.

The general condition remains good ; we need only mention the abundant sweats, and the absence, upon examination, of any special organic disorders.

Such—expressed in outline—is the usual condition of the patient in the paraplegic form of localised tetanus. Very rarely, however, is the clinical picture unmixed. We have already mentioned the unexpected appearance of generalised contractures, and in this connection we shall ask the reader to remember that there are, in addition to the true localised form of tetanus, two forms of generalised tetanus which writers on the subject have confused with the partial forms.

Sometimes the generalised contractures happen to mask, for a time, the initial paraplegic localisation ; this is what we have described as “the classic form of tetanus with paraplegic onset.”

Sometimes, on the contrary, tetanus exhibits an absolutely normal onset, with trismus, opisthotonus, and fever, and only subsequently does the affection more especially assume an increasingly definite paraplegic form. In addition to the classic tetanus paraplegic at the first onset, we must, therefore, recognise a generalised tetanus with *paraplegic development*, or a *secondary paraplegic form*.

Considering the evolution of these paraplegic partial forms, we shall at once perceive that it resembles that of the monoplegic form—that is, it is very slow—and we may distinguish four periods of development. Lastly, we may remark that the prognosis is favourable.

Diagnosis

In a late-appearing form of tetanus particularly—which means in the majority of cases—the total absence of a clinical history may for some days hold the diagnosis in abeyance.

It should always be an easy matter, after an attentive and thorough examination of the nervous system, to eliminate the paraplegias resulting from peripheral and radicular, or medullary, or cerebral lesions.

Three affections in particular, by their very similar initial symptomatology, simulate localised paraplegic tetanus with some exactness. These are, on the one hand, tetany and hysterical paraplegia ; on the other hand, cerebro-spinal meningitis.

We shall not insist upon the differential diagnosis of tetany and hysteria, which we mentioned when speaking of the monoplegic form.

This leaves us to consider cerebro-spinal meningitis, whose diagnosis is comparatively easy. It suffices to remember that the spasms are quickly replaced by paralysis, that there is intense headache, with photophobia, vomiting, and spinal pains upon pressure. The laboratory, moreover, provides us with exact information by the chemical and cytological examination of the cerebro-spinal fluid.

In cerebro-spinal meningitis lumbar puncture, which

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should always be practised directly there is the slightest suspicion of the possibility of a meningeal reaction, yields a turbid fluid, sometimes obviously purulent, with an increase of albumin, polynuclear reaction, and the presence of meningo-cocci.

CHAPTER V

LOCALISED TETANUS OF THE ABDOMINO- THORACIC TYPE

THIS variety of partial tetanic infection is quite exceptional. In the whole literature of medicine there is only one record of such a case of late and local tetanus. It developed one hundred and thirty days after the wound, and after the preventive injection of 10 c.c. of antitetanic serum.

The rarity of an exclusive and late-appearing tetanic localisation in the abdomino-thoracic muscles is such that we have decided to reproduce the unique and highly interesting observation published by P. L. Marie.

Observation (P. L. Marie)

C——, aged thirty-one years, who had already, in January, 1915, received a traversing wound in the left arm, after which he was given 10 c.c. of antitetanic serum, was again wounded, on the 10th July following, by shell-splinters, which caused numerous wounds of the face, the scalp, the upper part of the thorax, the left arm, and the left lower leg. Nearly all were superficial and of very small dimensions. Three deserve special mention: the first involved the left eye, of which the cornea was perforated and the lower lid lacerated; of the other two, which were fairly extensive and penetrating, one was situated in the left forearm and one on the inner face of the left thigh. Two days after the wound 10 c.c. of antitetanic serum were injected, without anaphylactic symptoms. On the 13th July, at the *Centre ophtalmologique* in Rouen, enucleation of the eye was performed, followed, four days later,

by the incision of a phlegmon in the forearm, with extraction of a splinter. Finally several operations were performed with a view to blepharoplasty. During this time all the wounds had healed quickly, excepting that on the thigh, which left a small fistula which discharged very slightly.

About the 10th November the patient, until then in perfect health, began to complain of intermittent shooting pains in the abdomen, thorax, and loins, these pains being presently accompanied by persistent muscular contracture in the abdomino-lumbar region.

Suspecting an attenuated form of tetanus, chloral was prescribed (3 grammes per diem). However, far from improving, the condition became aggravated. From the 20th November sudden jerks occurred, spreading from the waist down to the feet, compared by the patient to electric shocks, occurring in paroxysms, which left the upper limbs unaffected. Finally, during the night of the 3rd December, disquieting respiratory disorders appeared : frequent respiratory pauses occurred, sometimes attaining a duration of fifteen seconds, followed by slight polypnoeas. On the 6th December the patient exhibited an intense contracture of the lower portion of the trunk ; the abdominal wall, slightly retracted, was incompressible, and presented the stony hardness so characteristic of tetanus. This contracture was permanent ; it was no longer accompanied by pain, and was of constant intensity.

The period of paroxysms of painful contracture was replaced by analgesic muscular rigidity. The dorso-lumbar muscles were also contractured, causing a marked exaggeration of the lumbar curve. The patient was able to sit down only with difficulty, by gripping the edge of the bed with his hands ; and the pain quickly forced him to lie down again. When told to pick an object from the floor, he was able to do so only with great difficulty, by flexing the knees to the maximum, the trunk retaining its stiffness. There was no other contracture, excepting a bare trace of trismus, the incisors being still capable of a division of 1·2 inches. The patient complained of a slight stiffness when he tried to open his mouth widely, but he was able to eat, drink, and speak without difficulty. The back of the neck and the upper and lower limbs were perfectly supple ; there was no Kernig's sign, but the walk was embarrassed, the patient complaining that he could not throw his legs forward.

The tendinous reflexes, normal in the upper limbs, were strong in the lower limbs, but notably more exaggerated on the left; there was no ankle or patellar clonus. The cutaneous reflexes were also stronger on the left, particularly that of the tensor fasciæ lata. On the inner face of the left thigh, by the upper edge of the femoral condyle, was the orifice of the little fistula already mentioned, which had dried up about a fortnight previously, and was covered with crusts. There were no disorders of the sphincters; and the respiratory symptoms had not recurred. The general condition was unaffected; there was neither fever nor emaciation. It should be noted, however, that there was a slight acceleration of the pulse (92), and an obvious exaggeration of the secretion of sweat; the whole body was moist, and the face was covered with a veritable dew.

The patient was given 40 c.c. of antitetanic serum by subcutaneous injection, without any subsequent reaction, and 4 grammes of chloral, and, five days later, a further 30 c.c. of serum.

For ten days the condition of the patient remained stationary. The exaggeration of the lumbar curve diminished slightly, but the abdomen was still as hard as before. There were no spasmodic paroxysms, no respiratory troubles. The reflexes were still greatly exaggerated in the left leg. The temperature remained normal, the pulse was about 80, and there was no constipation.

The fistula intermittently discharged a few drops of serous fluid.

Thinking that a foreign body was helping to maintain the suppuration, and that it had perhaps played some part in the development of the tetanus, and was an obstacle to its cure, M. Marie had the region of the knee radiographed. In this way a small shell-splinter was discovered on the inner face of the articulation, $2\frac{1}{2}$ inches below the orifice of the fistula.

On the 27th December a third injection of serum was given (40 c.c.) in order to guard against the eventual danger of a mobilisation of germs when the operation was performed, and on the following day the projectile was removed under a local anaesthetic. It was enclosed in a small cavity with thick fibrous walls, covered with a small quantity of pus which contained, in the midst of numerous polynuclear

leucocytes which were more or less cytolised, bacillary elements of various dimensions. The immediate culture of the germs covering the splinter in glucose agar (stab cultures) resulted in the development of a multitude of microbial colonies. In twenty-two hours the medium broke up, without giving off any odour. An examination conducted by Dr Ch. Aubertin revealed large bacilli with square ends, Gram-positive, having all the characteristics of *B. perfringens*; long slender bacilli, Gram-negative; a few curved bacilli, like the septic vibrio; and lastly, some diplococci, Gram-positive, which were rarer.

From the 31st December began a definite improvement. The abdomen became slightly compressible, the lumbar curve diminished, and the separation of the incisors now amounted to nearly two inches. On the following days the improvement was very marked, the abdomen becoming more supple; and about the 7th January the abdominal wall had become completely relaxed, even when the patient lay completely extended; the exaggeration of the lumbar curve had completely disappeared, and flexor movements of the trunk were performed with ease. On the 15th January there was no longer any trace of the abdominal contracture, and the maxillary separation was two inches. The tendinous reflexes of the left leg were once more normal, but the test of the left plantar cutaneous reflex still determined an exaggerated contraction of the tensor fasciæ lata.

The patient left the hospital, cured, on the 15th January. Seen a month later, he was in perfect health.

In this observation the tetanus was therefore confined to the abdomino-thoracic muscles, sparing all the remaining groups of muscles, excepting the masticatory muscles, which, however, were only very slightly affected.

The tetanic infection entered the system, as M. Marie justly remarked, by the wound on the anterior and internal face of the thigh. The toxin here secreted ascended along the branches of the lumbar plexus, the femoro-cutaneous nerve, and the internal cutaneous

nerve, finally reaching the corresponding spinal segment. Although the lower limb on the wounded side did not exhibit any stiffness, it would none the less appear to have been slightly affected, since an exaggeration of the tendinous reflexes was noted.

The development of this particular form recalls, as we shall see, that of the early or late-appearing localised forms already discussed.

During a first period, in short, there were paroxysms of painful contractures and intermittent jerks, which in this case were localised in the abdomen, and which spread to the lower limbs. These contractures were accompanied by disquieting respiratory disorders, which were, however, transitory, and might very likely be attributed to the extension of the contracture to the muscles innervated by the intercostal nerves.

This first period was followed by a phase of analgesic muscular rigidity, characterised by the hardness so peculiar to tetanus ; the lower half of the trunk of the patient observed by P. L. Marie seemed transformed into marble.

Lastly, the phase of progressive and lingering resolution appeared.

While the disease was passing through these different periods of development the patient's general condition was good ; there was no fever and no marked acceleration of the pulse. There was nothing to remark but the hypersecretion of the sweat-glands : a sign of known significance in tetanus.

The pathogenesis of this variety is like that of the other forms of localised tetanus, whether early or late-appearing ; and we shall presently see that in these cases an important rôle must be attributed to previous immunisation. As the result of an insufficient initial

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preventive injection, or rather the insufficiency of a single preventive injection in respect of a prolonged incubation or a secondary reinfection, the tetanus assumes a clinical aspect which is local, attenuated, and benign. The incomplete or partial immunity conferred limits the development of the tetanic symptoms, without, however, preventing the fixation of the toxin in certain medullary territories.

Finally, the prognosis of this variety, like that of all the partial forms of tetanus, is benign.

CHAPTER VI

ATTENUATED FORMS OF TETANUS, WITH SLOW DEVELOPMENT AND PROLONGED INCUBATION

IN addition to the monoplegic, paraplegic, and abdomino-thoracic forms which we have already described, we think it proper to mention the attenuated forms, with slow development and prolonged incubation, to which MM. Claude and Lhermitte have called attention, although these are not always partial varieties of tetanus. Our principal reason for mentioning these forms is that the disease presents such peculiar features that these may well deceive an observer who is not sufficiently forewarned.

In three of the cases reported by Claude and Lhermitte, in which the subjects were young, hardy soldiers, whose usual health was good, tetanus followed upon extremely superficial wounds of the limbs, inflicted by shell-splinters, making its appearance more than two months later than the date of the wound. There was nothing to lead one to expect the imminence of so serious a complication. The wounds, indeed, were by no means important, having suppurated only slightly, and being completely cicatrised, in two of these cases, a long time before the development of the first symptoms.

These latter consist of a slight stiffness, either of the muscles of the wounded limb, or, to begin with, of the masseters. These slight contractures permit the convalescent to perform the occupations of everyday life

without any particular difficulty ; then they become more clearly defined, increasing in severity, and extending to other areas. At this stage the muscles involved are no longer those of the wounded limb, and the masseters, but the musculature of the neck, and sometimes even that of the trunk. Nevertheless, the patients are still able to walk with ease, and their general condition is excellent ; they are, as a rule, regarded as suffering from neuropathic contractures.

When we examine such patients we are at once impressed by their peculiar and rather abnormal facial expression. The features appear as though congealed, and are unusually prominent ; the eyes are half closed by motionless, narrowed eyelids ; the mouth is pinched, and the neck is rigid ; when the patient is stripped one is struck by the prominence of the sterno-mastoid and cutaneous muscles. The latter are rendered even more obvious if the patient be told to open his mouth ; all the muscles of the face and neck contract, and the slender bundles of the cutaneous muscles are plainly outlined under the skin. The patient finds it difficult to open the mouth or protrude the tongue. The latter is thickly coated, and is marked with the imprints of the teeth ; the breath is fetid.

The same hypertonia may be observed in the muscles of the lower limbs, whose movements are slow and painful ; the upper limbs are free from this contracture, unless the initial wound is situated in one of them.

As a general thing this condition of muscular hypertonia is not interrupted by paroxysms of contracture, as in the classic form of tetanus, or else these paroxysms are extremely transient and difficult to detect. However, in two cases Claude and Lhermitte observed

paroxysmal crises, which spread to a large number of muscles, and which were extremely painful.

The general condition remains excellent, and the temperature shows no departure from the normal, or exceeds it but slightly.

This attenuated form of tetanus is accompanied by excessive hyper-excitability of the muscles and nerves to electrical stimulation, and an exaggeration of the osseous and tendinous reflexes, with clonus of the foot and saltation of the patella. In the neck, percussion of the insertions of the sterno-mastoids or the cervical trapezius causes a sharp and sudden contraction of these muscles ; in two cases percussion of the zygoma caused a sudden extensor movement of the head. These modifications of the reflexes are to be observed in the monoplegic form also, and in speaking of the latter we laid stress upon them as a differential sign distinguishing tetanic from hysterical contractures. In this connection also the hyper-excitability of the muscles and nerves under electrical stimulation, and the exaggeration of the osseous and tendinous reflexes, which is observed several weeks after recovery, constitute indications of the greatest importance in the difficult differential diagnosis of these attenuated and late-appearing forms and of hysterical contractures. The attenuated variety of tetanus, whose essential features we have just outlined, constitutes a highly individual form of the disease, by reason of its clinical phenomena no less than its slow development, its prolonged incubation, and the benign character of its prognosis.

CHAPTER VII

ETIOLOGY AND PATHOGENESIS

I. Etiology

Frequency.—The generalised form of tetanus, whether early or late, has long been known ; it is, comparatively speaking, a frequent affection. Localised tetanus, on the other hand, is excessively rare, and the number of definite observations is very limited. It is enough to refer to the chief observations reproduced in this volume to realise that records of the partial forms, early or late-appearing, are infrequent and of recent date. This, as we have already explained, may be largely due to the fact that the partial forms of tetanus were for a long time misunderstood, so that clinicians who were not familiar with them referred the localised contractures which they observed as following traumatisms to another cause. There is no need to read the old writers to realise the truth of this assertion. In Follin's *Traité de Pathologie externe*, published in 1867, that writer described, under the name of secondary traumatic spasms, an affection very similar to that which we have described : traumatisms were followed by convulsions confined to one member, with absence of trismus, and a fatal termination. Probably Follin had in his possession documents which enabled him to sketch the history of these traumatic spasms, and these latter, which by us are regarded as partial forms of

tetanus, are doubtless less rare than might be supposed. Their rarity, however, is explained by the undoubted fact that certain peculiar conditions are required for their development, and also by the fact that under certain conditions attenuated toxins may be developed, as we shall see when discussing the question from the pathogenic standpoint.

Cause.—The cause of localised tetanus of the members consists, as in all the other varieties of the disease, in the introduction into the system of the toxins secreted by Nicolaïer's bacillus, with which a wound has been infected.

Causal Agent.—The bacillus of tetanus was discovered in 1883 by Nicolaïer, in the pus of animals which he had rendered tetanic by inoculation with small quantities of earth.

Kitasato first isolated and cultivated it, and by demonstrating that inoculation with cultures of the germ gave rise to tetanus he proved its specific character. The important labours of Vaillard, Vincent, and Rouget determined the conditions under which tetanus is able to develop. Finally, the study of the toxin secreted by the tetanic bacillus enabled Roux and Vaillard to obtain a serum whose preventive action no longer calls for proof.

Morphology.—*In the pus of the tetanic wound* the bacillus occurs in the form of a rather slender, elongated rod, the ends of which are not rounded. It measures, on an average, $4\ \mu$ in length and $0.3\ \mu$ to $0.4\ \mu$ in thickness. It is usually devoid of spores.

In cultures its aspect differs according to the age of the latter.

During the first few hours of its development in bouillon it presents the same form as in pus; but at the

end of eight hours it begins to sporulate. The tetanic bacillus then appears as a slender rod bearing upon one of its extremities a spherical, refracting spore, which gives the germ the form of a pin. At the end of a few days all the bacilli have sporulated. About the tenth day the bacillus proper atrophies, and later still it disappears from the culture, leaving only the spores.

Mobility.—Examined in the fresh state, in the absence of oxygen, the bacillus which has not yet sporulated is slightly mobile. Its movements are slow and sinuous. As soon as the spore has formed this mobility disappears.

Staining.—The basic aniline dyes will stain the tetanus bacillus satisfactorily. The sporulated bacilli take the stain only in their bacillary portion ; as for the spore, only the outline is stained, the centre remaining colourless. To stain the central portion of the spore one must employ the special methods for the staining of spores (Moeller's process, for example). The tetanus bacillus is Gram-positive.

Lastly, before the spore has formed the bacillus is provided with numerous vibratory cilia, which are attached laterally.

Cultures.—The tetanic bacillus is readily cultivated in anaerobic media, but cannot support the presence of any very appreciable quantity of oxygen. The usual media may be employed, provided they are prepared with fresh bouillon (Kitasato). It does not readily multiply in media with albuminous bases, but cultures made in rabbit serum are extremely virulent.

In bouillon, after twenty-four hours, a homogeneous turbidity is observed, which continues for some days ; about the fourteenth or fifteenth day the culture sinks to the bottom of the tube and the liquid becomes clear. From the first day bubbles of gas are seen on the surface.

These cultures give off a disagreeable odour, recalling that of burnt horn.

On gelatine cultures obtained by deep punctures (to avoid the deterrent effect of oxygen) and maintained at a temperature of 20° C. the cultures make their appearance about the fifth day. In the region of the puncture cloudy spots are formed, from which fine needle-like formations extend in a perpendicular direction. These cultures spread more and more, until about the tenth day the gelatine liquefies in the lower portion of the tube, remaining intact in the upper portion.

The isolated colonies occur in the form of tiny spheres, of a cloudy appearance, from which grow tufts of fine needle-like filaments ; these colonies are surrounded by tiny bubbles of gas. When, on the tenth day, the gelatine liquefies, the colonies appear as tuft-like formations swimming in a round cupule of liquefied gelatine.

On agar the culture is cloudy, without any very distinctive characteristics. The medium is broken up by numerous bubbles of gas.

On potato the development is poor.

In milk the cultures develop readily, and the medium is not coagulated.

Biological Properties.—Vitality.—The spores of the tetanus bacillus are highly resistant. Heated in a closed flask in a moist medium, they will support boiling for four or five minutes without perishing ; while they resist a temperature of 80° C. for as long as six hours.

Dried in an albuminous medium (serum, blood, etc.), Maljean found that they frequently survived heating to 40° C. in steam, under pressure, for fifteen minutes.

If protected from the air and light, their vitality persists for several years. Mingled with blood or pus,

and sheltered from the light, they retain their virulence for a long time.

Mocard has found them living after a lapse of eighteen months upon articles which had been employed in connection with colts which had died of tetanus.

Eiselberg succeeded in giving tetanus to an animal by inoculating it with a splinter which had been extracted from the hand of a tetanus patient, and had been kept for two and a half years in a cupboard.

Formation of Indol.—Cultures in bouillon are rich in indol.

Formation of Gas.—The gases which are given off by the cultures are nitrogen, hydrogen, and hydrocarbons.

Hæmolysin.—According to Ehrlich and Madsen, filtered cultures of tetanic bacilli contain a substance differing from the toxin, which dissolves the red blood corpuscles of the majority of the domestic animals. This tetanolysin is very unstable; it is rapidly destroyed if heated to 50° C. (in twenty minutes); exposed for five hours to a temperature of 20° C. it loses half its power, only a temperature of 0·0° C. enabling it to retain its activity for twenty-four hours. Tetanolysin is precipitated by sulphate of ammonia. The resulting powder, if desiccated, keeps for a long time.

Agglutinability.—The bacillus, as we saw when considering the diagnosis of tetanus, is not agglutinated by the serum of a human being or an animal suffering from tetanus. With the serum of a horse vaccinated against the tetanic toxin agglutination may be effected by very minute proportions: 1 in 2000 and even 1 in 5000 (Courmont).

Experimental Pathogenic Action. — Animals, in general, are susceptible to the tetanic infection. In the

laboratories the mouse, rat, and guinea-pig are employed by preference; the dog is highly refractory, while the domestic fowl and the pigeon are completely so.

To obtain experimental tetanus it suffices to inject under the skin or into the muscles of the thigh of a susceptible animal a small quantity of some medium containing tetanic bacilli or spores.

Inoculation with Tetaniferous Pus or Soil.—Pus collected from a tetanic wound is inoculated under the skin of an animal. At the point of inoculation a more or less extensive tumefaction is produced. Three or four days later contractures appear, first in the neighbourhood of the region inoculated, but later they become generalised; convulsive attacks occur as a result of the slightest excitation. The animal succumbs thirty-six to forty-eight hours after the onset of tetanus.

At the autopsy a purulent centre is discovered at the point of inoculation; this contains, in addition to the germs of suppuration, a few specimens of tetanus bacilli. This pus may, with success, be employed to inoculate other animals, but after three such passages the results are negative (Vaillard).

The viscera appear normal, except for a passive pulmonary congestion due to pre-mortem dyspnoea. By injecting tetaniferous soil under the same conditions, the same results are obtained; but at the point of inoculation a dry eschar is often produced, or a pseudo-membranous exudate due to the existence of associated germs.

Inoculation with Pure Cultures.—Subcutaneous, intramuscular, intravenous, intraperitoneal, or subdural inoculation gives rise to a typical tetanus. The

introduction of the germ by the digestive tract produces no result.

Young cultures, as a rule, are not very tetanigenous, as they contain but little toxin.

It is interesting to note that in all cases, no matter what the mode of inoculation, the blood remains sterile.

Tetanus Toxin.—The bacillus does not become generalised. The general signs are due to the action of a poison elaborated by the germ and diffused throughout the organism. The existence of this toxin was demonstrated for the first time in 1890, by Kund Faber ; it has been very fully investigated by Vaillard and Vincent.

Method of Preparation.—The tetanus bacillus is inoculated into a spherical flask containing fresh peptonised bouillon. This is placed in an incubator, which is kept at a temperature of 37° C. for eighteen to twenty days. It is then filtered through a Chamberland filter ; the filtrate obtained exhibits an alkaline reaction, and gives off the characteristic odour ; it is highly toxic, for a dose of .001 c.c. kills a mouse.

Nature and Properties of the Toxin.—The earliest investigations gave rise to the hypothesis that the tetanic toxin was a ptomaine (Brieger). Others attributed to it the properties of the alkaloids. Ehrlich considered that it was composed of several substances : one being tetano-spasmin, an energetic convulsive agent, and another tetano-lysin, possessing no tetanising properties. In reality, the tetanic toxin may be likened to the diastases. Like them, it is greatly modified by exposure for half-an-hour to a temperature of 65° C., and exposure for three hours to a temperature of 80° C. kills it.

In a closed vessel, protected from light and air, it

may retain its toxic power for four months. Exposed to the air for one month, it loses a great part of its activity ; and the action of the air is greatly accelerated by the simultaneous action of sunlight.

Evaporated in a vacuum over sulphuric acid, at ordinary temperatures, the toxin is reduced to a brown residuum, amorphous and highly toxic. If absolute alcohol be added, the latter dissolves a portion of the residuum, which after evaporation is non-toxic. The portion insoluble in alcohol is freely soluble in water, and readily produces tetanus in animals. The dialysis of this tetanic substance is a rather slow process. Lastly, like the diastases, the tetanus toxin adheres to the precipitates of phosphate of calcium and aluminium which are thrown down from it upon the addition of chloride of calcium ; if these are carefully washed in sterile water and inoculated under the skin of the guinea-pig, the latter contracts tetanus.

According to Courmont and Doyon the tetanus toxin is merely a soluble ferment, devoid of toxicity in itself, but able to cause a fermentation of certain substances in the organism ; the true toxin results from this. This interpretation has not been accepted by other writers. Lastly, the toxin may sometimes be found in the blood of tetanic patients.

The Mode of Action of the Toxin.—The tetanic toxin is a poison of the nervous system, its special affinity for the latter having been demonstrated by the classical experiment of Wassermann and Takaki. The toxin was mixed with pulped cerebral matter, and subjected to centrifugalisation. The resulting liquid was devoid of toxicity, although the toxin was not destroyed. Roux and Borrel proved that it was fixed and immobilised by the nervous system, and then,

according to Metchnikov, absorbed and digested by the leucocytes.

The investigations of A. Marie show that the toxin attacks the nervous system in two ways. One portion of it passes into the circulation, where it is fixed by the nerve-cells; the other portion is absorbed by the peripheral nervous filaments, which gradually carry it, along the axis cylinders, to the nervous centres.

Habitat of the Tetanic Bacillus.—Now that we have considered the tetanic bacillus and its toxin, we have still to inquire into the habitat of the bacillus—a question of particular importance from the purely hygienic point of view.

Very often the occasional circumstances of the traumatism throw light upon the etiology of the disease. For the rest, the following remarks apply equally to all the clinical varieties of tetanus:

The Soil.—All authorities are at present in agreement as to the telluric origin of the tetanus bacillus. The spores of the tetanus bacillus are frequently found in the excrement of the horse. It is already some time since Sanchez-Toledo and Veillon proved that the tetanus bacillus is a frequent inmate of the intestine of the herbivora, and in particular of the horse. The bacillus, accordingly, occurs principally on the surface of the soil. At a depth of twelve inches it is rarer; on the other hand, it swarms in manure, or on dung-hills. In the present war the infection may be derived from the wound itself, which is contaminated by dust, or even by particles of earth (owing to the ricochet of bullets or shell-splinters). It may also occur directly, at the moment when the wounded man falls to the ground, or while he is lying on it. Infection may also be due to clothing covered with earth or mud which

contains tetanic germs. Or again, infection may be directly effected when the wounded man crawls over the ground in search of cover. It is probable that the great frequency of tetanus in the present war is due to the extensive earthworks necessitated by trench fighting.

It must be remembered that the soil contains more or fewer bacilli in different regions. There are tetanigenous centres—that is, centres where tetanus is more frequent than elsewhere. This fact has long been noted by veterinary surgeons, and is abundantly proved by a survey of the cases of tetanus which have occurred during the present war. Belgium and the regions at present invaded are said to be tetanus countries. Dr Paul Guillon states that the Marne contains tetanic belts—that is, districts where tetanus frequently occurs—while elsewhere it is of infrequent occurrence. It has been stated also that the soil of the Aisne valley contains far more tetanic germs than the soil of the surrounding districts. According to Bowby, tetanus was less frequent after the battles around Ypres than in the valley of the Aisne. Possibly the germs, like the flora, are affected by conditions arising from the mineral composition of the soil. The rich clay of Flanders is perhaps less propitious to the cultivation or dissemination of tetanic spores than the dusty, calcareous soil of Champagne. Let us note, lastly, that it is said that in England wounds are infected chiefly by staphylococci and streptococci, while in France one finds principally anaerobic microbes, the tetanus bacillus, the bacillus of gas gangrene, and the bacillus of malignant oedema (Dutertre).

The existence of soils rich or poor in tetanic spores has been scientifically verified. There are no pure cultures of tetanic germs in the soil; perhaps it is to

the association of the germ with other microbes that the extraordinary virulence of the tetanus bacillus is due, when found in mixed infections. The importance of these microbial associations has long been known. Because of these associations, or the presence of foreign bodies, or again as a result of the attrition or destruction of tissues, the phagocytes, being otherwise employed, fail to prevent the microbial invasion. These associated microbes favour the tetanic infection.

Straw.—We must not fail to remark that while contact with the soil is dangerous, contact with straw which has been more or less contaminated by the ground upon which it has lain may also become a source of infection.

The manner in which the wound is inflicted.—The foregoing considerations explain the varying frequency of this complication according to the cause of the wound and the manner in which it is inflicted. It is obvious that there is every probability that the bullet which has not ricochetted carries no tetanic spores with it. This is not the case with splinters of percussion shells ; the shell having burst in the ground, its splinters almost invariably carry particles of earth with them, as does the ricochetting bullet. Doubtless in pursuance of this idea it has been said that tetanus almost always occurs as a result of wounds caused by artillery projectiles.

Any extensive wound of the soft tissue should be regarded as suspect.

Bullet wounds also yield a high percentage of tetanus (Dutertre).

Among 129 cases of tetanus Bazy cites, from the German periodicals, 9 cases due to rifle bullets.

Fragments having plane surfaces are more likely to

drag shreds of clothing into wounds than pointed bullets, which simply perforate the clothing when they strike point foremost ; and we have seen that fragments of clothing contaminated by the soil may very well be the vehicles of tetanic spores. Although it is difficult to forecast tetanus, the manner in which the wound has been contaminated, and above all the carrying of shreds of clothing, with a mixture of grains of sand and little stones, into the wound, are valuable indications.

The situation of the wound is also an important factor, as will readily be understood. Wounds of the extremities are most liable to come into direct contact with the soil, and they are therefore most readily infected. The wounded man, in falling, throws his hands forward as far as possible ; the man wounded in the leg or foot bears a wound peculiarly exposed to the dust rising from the soil.

Some statistics of Madelung's bearing upon the situation of the wound by which infection enters are significant in this connection. In 166 cases of tetanus the head was wounded five times ; in 8 cases the trunk alone was wounded ; in 50 cases the lower extremities only ; while in 103 cases there were multiple wounds : wounds of the upper and lower extremities. In no case did tetanus result from a pulmonary wound : perhaps because of the richness in oxygen of the pulmonary tissues. The predominance of wounds of the lower extremities has long been known.

The Nature of the Wound.—This, perhaps, is not so important, in respect of the genesis of tetanus, as some would have it. Nevertheless, it is enough to examine the statistics, and we realise that tetanus is encountered more particularly in cases where there is great destruction of muscular tissue, and opening of articulations,

with abundant suppuration. In many of these wounds, moreover, at all events in this war, either shell-splinters are found, or fragments of straw contaminated by the soil, or shreds of uniform, with tetanic spores.

We have every justification for saying that while bullet wounds may give rise to tetanus, suppurating wounds of the lower extremities are predominantly those which are most frequently complicated by a generalised or localised tetanic infection.

Adjuvant Factors.—Atmospheric Conditions.—Heat is a factor which favours the tetanic infection. We know that when guinea-pigs inoculated with tetanic spores, without toxin, are placed in an incubator heated to 40° C. for two or three days, they contract a super-acute tetanus, developing as a splanchnic tetanus, the bacillus being generalised through all the tissues. In the case of guinea-pigs infected thirty to sixty days previously, and then placed in the incubator under the same conditions, tetanus is still produced. These facts are explained by the destruction of the phagocytes under the influence of these high temperatures, this permitting the germination of the spores, which were immobilised in the leucocytes.

Cold.—Cold is also regarded as a factor favouring the appearance of tetanus, so care should be taken that a man seriously wounded does not become chilled.

Humidity is regarded by Schultze as a factor favouring the development of tetanus. We do not believe in the existence of this atmospheric influence, for the microbes occurring in dust are disseminated everywhere in dry weather, and find the conditions necessary to their development in the moisture of wounds.

Secondary Infection.—The part played by microbic associations in the production of tetanus is considerable.

This is proved by the experiment conducted by Vaillard and Vincent.

Under the skin of the guinea-pig were injected spores free from toxin, incapable of producing tetanus alone ; at the same time 0·5 c.c. of a culture of *microbacillus prodigiosus* was injected. Thirty-two hours later a mortal tetanus developed. It may be that the phagocytes seized upon the latter germ, ignoring the tetanic spores, which were able to germinate at leisure and secrete their toxin. This fact explains how soil which is extremely poor in tetanic spores may cause tetanus in man or beast, thanks to the common microbes which it contains, which play an important part in favouring the development of tetanus. This part, however, is not common to all germs. Vaillard and Vincent were unable to produce tetanus when the associated microbe was a staphylococcus, a streptococcus, *Bacillus subtilis*, or the pneumo bacillus. In order that a tetanic product may produce tetanus, the presence is necessary :

1. Of the tetanic bacillus, or tetanic spores.
2. Of a micro-organism capable of favouring its germination.

The Action of Chemical Substances.—According to Vincent, the salts of quinine act in the same manner as lactic acid, appearing to favour the tetanic infection when injected simultaneously with spores without toxin. Moreover, if in the case of guinea-pigs which have been inoculated with spores some days previously, and have remained healthy, a quinine salt be injected under the skin, tetanus breaks out, and the tetanic bacillus, which had remained in a latent condition, behaves as though attracted to the point where the quinine is injected, multiplies there profusely, and becomes generalised, even throughout the viscera. We

shall presently discuss the importance of this fact from the standpoint of prophylactic hygiene.

Direct Contact.—Lastly, there may be a danger of transmitting tetanus from one patient to another, hence the necessity of isolating tetanus patients and appointing special attendants. The present war has given us several confirmations of this etiological hypothesis. Dutertre records the history of three wounded men, who at Douai were placed in adjacent beds, and were attacked by tetanus. There is also the case of five wounded men who were put to bed in the same room, one beside another. Three of them had been infected in action ; forming part of the same regiment, and wounded at the same time, they had lain side by side on the battle-field. The three first gave tetanus to the two others, by touching their dressings with their hands.

We must add that the transmission of tetanus may also be effected by flies.

II. Pathogenesis

The history of the atypical forms of tetanus raises an interesting pathogenic question. It seems that in localised tetanus preventive serotherapy preserves the bulbar centres. The infection seems to be attenuated by incomplete serum immunisation. We know, experimentally, that an injection of toxin sufficient to provoke a generalised form of tetanus will give rise to an atypical form only if followed by an injection of serum within a period not exceeding two hours. In certain cases also there may be question of bacilli less virulent than normally ; the attenuated toxins would then act only upon the nerves of the injured member (monoplegic tetanus), or on one medullary segment

(paraplegic tetanus, tetanus of the abdomino-thoracic type).

This hypothesis is supported by the majority of those writers who have recorded cases of partial tetanus, and in particular by Pozzi, Carnot, and Laval ; and it is all the more probable in that we are able, by injecting a weak dose of culture into an animal, to provoke contractures localised to the infected limb. In short, an atypical form of tetanus results. Thus if we inject, into the hind leg of a guinea-pig, an extremely weak dose of tetanic toxin, incapable of producing a fatal result, we obtain a typical local tetanus which is strictly confined to the inoculated limb. The contracture is rigid, and persists for some weeks. The action of the toxin does not proceed beyond the spinal cord segment innervating the inoculated limb, and exhausts itself there ; it does not attack other nervous centres. The comparison of such an experiment with actual clinical examples is always of the greatest interest. Klemm does not hesitate to assert that if we were carefully to observe wounded men who develop tetanus from the first, we should always find an initial local contracture in the region of the wound which admitted the tetanic infection.

As we have already remarked, in connection with our communication to the Academy of Medicine in January, 1916 (Obs. XVI.), there are two factors which enable us to explain localisation, early or late, in a wounded limb or a given anatomical region. These are, on the one hand, an incomplete preventive serotherapy ; on the other, the existence of bacilli of a low degree of virulence, few in numbers, and secreting attenuated toxins. These two factors may act in conjunction or singly.

Another question arises : What is the mechanism by which a preventive injection localises the tetanic infection ? Is the virulence of the toxin secreted neutralised or attenuated, or does the preventive serum place the nervous system in a condition of defence, enabling it to check the ascendant progress of the toxin ? This latter conception is plausible, and it seems highly probable, if we consider that the serum is preventive rather than curative, that the antitoxin, the moment it is injected, checks the further production of toxin, or, rather, destroys it as soon as produced in the region of the wound.

The secretion of the toxins being thus arrested, when the quantity acting upon the nervous system is the result only of a short lapse of time—the period dividing the moment of the wound from the moment of the injection—the dose in circulation is too small to become widely diffused, and to act directly upon the entire nervous system ; it localises its action upon the nerves of the wounded limb and the corresponding spinal segments.

CHAPTER VIII

DEVELOPMENT AND PROGNOSIS

Development.—Generally speaking, the localised and atypical forms of tetanus and the partial forms of tetanus of the limbs are characterised by a slow development, with a tendency toward recovery. Owing to the long duration of the different periods of the infection, sequelæ may occur, veritable complications, which are usually of a transitory nature. Sometimes, however, these sequelæ are permanent, if the physician is not careful to guard against them or combat them directly they make their appearance.

The development of the localised forms of tetanus is sub-acute or chronic. It does not appear, to judge from the pathogenic conceptions expressed in the foregoing chapters, that an acute local tetanus can exist.

It is true that Vincent and Wilhem published, under the title of *Localised Tetanus*, details of a case of tetanus which was confined to the lower limbs, with contractures in hyper-extension, in which death occurred in twenty-four hours, as the result of grave pulmonary phenomena which were shown by an intense polypnoea. If this observation be analysed it plainly appears that the patient exhibited the signs of a tetanic infection which should rather have been classified as a super-acute generalised form of tetanus, in which the toxin was rapidly diffused throughout the system.

Owing to an extremely rapid development, the

clinical signs had no time to reveal themselves ; the symptomatology therefore remained that of the more attenuated forms, giving the appearance of being localised.

As regards the monoplegic and paraplegic forms, whether early or late-appearing, we have seen that the period of incubation is fairly long : a fortnight or three weeks in general, and sometimes more. Once the first clinical signs make their appearance the disease develops through two or three well-defined periods. The first, which we have already described in detail, is characterised by a permanent contracture of one member, or of two symmetrical members, and by painful paroxysms affecting the same region. This first period lasts, on an average, ten to twenty days, sometimes more, as in our own observation.

A second period usually follows : a period of permanent, non-painful muscular rigidity. The contracture is no longer accompanied by painful paroxysms, and the permanent rigidity immobilises the patient as a complete monoplegia or paraplegia with extreme contracture would do. This is a period of long duration, and if we examine, for example, the observations published by Demontmerot, which deal with the paraplegic form, we find that in one case the rigidity persisted for twenty-one days ; in another case for forty days ; and in a third for forty-nine. Demontmerot regarded this second period, with its peculiar nature and long duration, as characteristic of the paraplegic form. However, it is nothing of the kind, for the same persistent stiffness of the limb attacked by the tetanic infection has been noted in the monoplegic forms. Courtellement, who was the first to publish an observation of tetanus localised in one limb, had already

insisted upon this point ; and Pozzi's patient still exhibited this second period of non-painful contracture after the lapse of more than forty days. More than a month after the termination of the first period of development, Pozzi wrote that his patient's left lower leg was flexed at a right angle to the thigh by the powerful contracture of the flexor group of muscles, whose contracted tendons could be felt under the finger in the region of the popliteal space. There was also a slight contracture of the adductors. The extension of the leg was consequently absolutely impossible ; moreover, the gastrocnemius was hard and rigid as a woody mass.

This period is often followed by a third and last period, during which the sequelæ of the preceding symptoms establish themselves, develop, or disappear. There may be a musculo-tendinous shortening ; this is especially frequent in the gastrocnemius and the tendo Achillis, as in our own observation (XVI.). In the case described in this observation there was a very marked retraction of the tendo Achillis, which prevented the convalescent patient from placing his heel on the ground when walking. Trophic disorders, muscular or cutaneous, may be observed. Muscular atrophy in particular is frequent ; it is sometimes slight and sometimes severe. Perforating ulcer of the sole has been observed.

Lastly, vaso-motor disorders may appear. These complications can, in some cases, be foreseen and obviated by early massage.

It will readily be understood that these complications involve a very long and troublesome convalescence, representing the fourth period of the disease.

It follows that the total duration of the malady in the monoplegic, paraplegic, and abdomino-thoracic

forms may amount to one, two, or three months, or even longer. In addition to these sub-acute forms, it will be remembered that there are forms even later-appearing, more attenuated, and longer in developing. Thus, in the attenuated forms, we have seen that the development is extremely slow, owing to the fact that the infection is attenuated by a previous preventive serotherapy.

Prognosis.—The localisation of the tetanic infection may be regarded as a sign of the benignity of the disease. It must not be supposed, however, that recovery is the rule. Partial tetanus is a serious malady, on account of the complications which may supervene, and the possible secondary generalisation of the infection.

The gravity of atypical tetanus is demonstrated by the observations of Routier. This author recorded three deaths among six patients. However, in the majority of cases, partial tetanus of the members develops in the direction of recovery, if we except the late-appearing post-operative forms, whose prognosis is not always so benign as that of the retarded forms which occur without operation. While in some cases the disease assumes an acute form, of the ordinary type, which is rapidly fatal, the usual progress of the disease is less rapid. The onset is commonly insidious, the contracture installing itself slowly and progressively, localising itself in the wounded limb, often accompanied by slight trismus and stiffness of the neck. No paroxysmal crises are observed, or only late-appearing paroxysms of little severity. Of the contractures, one of the most constant and persistent is that of the abdominal muscles.

The temperature is almost normal. Despite the

sub-acute form of the disease, and its insidious advance, the various signs which we have just recalled may finally become aggravated, terminating, after the lapse of several weeks, in contracture of the respiratory muscles and asphyxia.

According to Bazy, death occurs in one case out of two or three, according to the nature of the cases. But if we consider only the observations following upon operative intervention, the prognosis is even more gloomy ; there were six deaths out of seven cases successively reported by Berard and Lumière, Querin, and Leriche and Desplas.

In atypical tetanus it seems as though we cannot seriously base our prognosis of the malady, or a forecast of its development, upon symptomatology. Although it is the rule, in the classical form of tetanus, to regard the prognosis as intimately connected with the length of the period of incubation and the temperature, this is no longer the case in the abnormal forms of tetanus.

The period of incubation, as we have many times repeated, is extremely variable. It may be long or short, but the prognosis does not appear to be affected thereby. We will merely remind the reader that the localised forms of tetanus, and their pathogenesis enables us readily to understand this, do not develop, as may happen with the ordinary forms, within a few hours of the wound ; a fact which explains why the symptoms never appear in a tumultuous fashion, rapidly followed by death. But the indications furnished by the duration of the incubation period must not be regarded as absolute, even in the classical form. Thus Vautrin, addressing the Society of Medicine of Nancy, reported cases of acute tetanus whose onset was extremely tardy—the periods of incubation being

twenty-two and fifty-four days. Comparatively benign cases with a brief period of incubation are, however, very exceptional.

In the classical form of tetanus the temperature is, as a rule, a great help in establishing the prognosis. We know that pronounced hyperthermia and extreme frequency of the pulse are unfavourable signs. In the abnormal forms, and especially in partial tetanus, conclusions drawn from an examination of the temperature are, as we have already explained at some length, of little value. The two examples reported by Routier are a striking proof of this assertion ; in both cases the temperature never rose above $102\cdot2^{\circ}$ F., yet death supervened : in the one case fourteen days after the commencement of the tetanic symptoms, and in the second case two days after the appearance of a slight trismus, and painful contractions in the region of the elbow. However, it sometimes happens that the temperature furnishes no indications, even in the purely classic form of tetanus. A case has been recorded in which the temperature never exceeded $100\cdot4^{\circ}$, and the pulse 90 to 96 per minute, but which terminated in death, despite the apparent benignity of the general symptoms. The acceleration of the pulse and respiratory disorders are elements of gravity even in the partial and atypical forms.

A pulse which is now almost normal, now very rapid, and a jerky respiration, are reasons for reserving the prognosis.

The permanent and progressive contracture of the abdominal muscles is, as we have stated, an almost constant symptom in the partial forms of tetanus ; and according to Bérard and Lumière it should be regarded as of great importance from the prognostic point

of view. We know that these writers regarded this contracture as the prelude to contracture of the respiratory muscles and asphyxia.

With Routier, we do not believe that the prognostic importance which Bérard and Lumière attribute to it should be attached to this sign.

Still, one should always look out for this contracture, as when associated with modifications of the pulse and the temperature it may give us reason to forecast a fatal termination. We repeat once more that as this symptom is almost the rule in cases of partial tetanus, whose prognosis is, after all, comparatively benign as compared with that of the normal and usually observed form of the disease, its presence must not be regarded as a prime factor in the establishment of a positive prognosis.

To judge of the probable termination of a case of abnormal tetanus, we must also consider how far the deglutition and the functions of the larynx are affected. Again, the favourable action of narcotics upon the cramps should be regarded as a favourable sign.

Finally, if we are to believe Dr H. Gordon (*The Lancet*, 31st December 1914), the prognosis is peculiarly dependent upon the association of the tetanic bacillus with other virulent bacteria, and especially with the anaerobic bacilli of Welsch. We know, too, that tetanus is frequently associated with gas gangrene, the bacilli of both diseases being anaerobic.

To sum up: The abnormal forms of tetanus owe their benignity to their localisation, but they none the less constitute a serious malady, which necessitates prompt treatment; and this treatment, as Étienne observes, must combat the three phases of the disease: infection, intoxication, and cellular reaction. In spite

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of everything, therapeutics, which calls for combined treatment, may prove inactive, when the disease terminates in death from asphyxia, due to the tetanus of the respiratory muscles, although the muscular contractures may not have become generalised. Death is not always the result of the contracture of the respiratory muscles, and Quincke even claims that in many sufferers from tetanus it results, on the contrary, from the complete relaxation of the respiratory muscles—that is, from their paralysis.

It is also certainly the case that death may be the consequence of a secondary generalisation of the tetanic infection: in other words, of a septicæmia, of a tetanic poisoning, or even of a pulmonary complication, such as the pneumonia of deglutition.

CHAPTER IX

TREATMENT

WE propose to describe, in this chapter, the various treatments which have been successively recommended for the prevention of tetanus, and to cope with the disease when developed.

All that follows may be applied to the classic forms as well as to the atypical varieties of the tetanic infection. We shall give a brief final summary only of such matters as have especial reference to the abnormal forms, and shall indicate the treatment which appears to us most rational and efficacious.

We shall consider successively :

1. The prophylaxis of tetanus.
2. The treatment of tetanus properly so called.

First of all we shall emphasise the necessity of local treatment—that is, the treatment of the wound, by which the infection enters the system—and shall then proceed to deal with the general treatment, which should be specific and symptomatic.

Prophylaxis of Tetanus

We have seen that Nicolaïer's bacillus remains generally localised in the wound, and in the wound the toxin is manufactured. It follows from this that the prophylaxis of tetanus, which must be local and general, is based upon two fundamental principles :

- (a) The complete cleansing of the wounds.
- (b) Preventive antitetanic serotherapy.

Local Treatment of the Wounds

It is absolutely necessary to attend to every suspicious wound ; to rid it of the tetanic bacilli which may have contaminated it, and to prevent the subsequent growth of the germs.

An extensive cleansing of wounds should always be effected, removing the particles of earth and the shreds of clothing carried into the wound by the projectile ; lastly, a search must be made for any foreign bodies. In a word, the wound must be freed, as far as possible, from bacillary infection.

Amputations.—Obviously the means of cleansing a contaminated wound which at first sight appeared most effectual was to suppress it and replace it by a new, aseptic wound : hence the idea of amputating limbs with septic wounds. Thereby the introduction of fresh toxins into the circulation is prevented. Formerly, indeed, ablation and excision of the wound was recommended, and even the amputation of the extremities. It has fortunately been demonstrated that this procedure, which was indeed unduly radical, was ineffectual. Experience has shown that owing to the invasion of the nervous system by the toxin, mutilating operations can at most do no more than prevent the introduction of further toxins.

In our experience amputations do not prevent the outbreak of tetanus ; even in cases of serious injury to the limbs this procedure, in our opinion, should be rejected.

The Search for Projectiles.—When these are not too deeply situated, they should be sought for as promptly as possible, with the aid of the X-rays or the various apparatus devised for the purpose of discovering foreign

bodies (Bergonié's or François' electro-vibrator, etc.). Foreign bodies may serve as the nidus for Nicolaïer's bacillus and the other anaerobic germs which favour tetanic tox-i-infection. By removing a shell-splinter, or a bullet, we diminish the probabilities of suppuration, and enable the cicatrisation of the wound to proceed more rapidly. Moreover, this procedure enables us to rid the wound of tetaniferous contaminations, and to avoid a secondary intervention, which may become, as Bérard and Lumière have shown, the occasion of renewed virulence on the part of the tetanic spores, and the origin of a late tetanus, localised or otherwise.

This search for foreign bodies offers, therefore, a two-fold advantage from the point of view of prophylaxis.

If we consider the cases of tetanus, atypical as well as classical, which have occurred during the present war, we find that asepsis and the mere cleansing of the wounds is not sufficient to prevent the development of tetanus.

Antisepsis.—In war surgery the antiseptic method must be employed. Although antisepsis is out of fashion nowadays, surgeons quickly realised the necessity of discovering antiseptics which would act upon the bacillus of tetanus.

Chemical Agents.—*Tincture of Iodine.*—*In vitro* tincture of iodine neutralises the tetanic toxin, but it must be remembered that in spite of the constant and systematic employment of iodine upon wounds received in battle, tetanus has appeared with comparative frequency.

Oxygen. Nicolaïer's bacillus being anaerobic, the idea arose that it might be destroyed by bringing it into contact with oxygen. For this purpose oxygenated water was employed, and hyper-oxidised substances

which readily liberate oxygen. Oxygen, moreover, acts not only on the bacilli, but also on the toxins which they secrete.

This property of the tetanic germ, of developing in the absence of oxygen, known as anærobiosis, provides therapeutics with a valuable means of attacking the tetanus bacillus. Numerous preparations possess the property of liberating oxygen at the surface of a wound ; oxygenated water may be used in this way, or magnesium peroxide.

All wounds which have been contaminated by the soil, by shreds of dirty clothing, or by a foreign body, are suspect from the point of view of tetanus. Such wounds must therefore be cleansed with oxygenated water or powders which give off oxygen. The same with old wounds which have given rise to tetanic infection : no good result can be obtained save by acting upon them with oxygen. The tetanic bacillus is killed by oxygen, and the gas, especially in the nascent state, slowly cleanses the wound, destroying toxins, detaching shreds of fat, clots of blood, and dead tissues, without ever exercising any harmful action (Dutertre).

Certain writers have, while experimenting, observed a fact of great interest and importance—namely, that the toxicity of various toxins is destroyed by the peroxides. They have succeeded, by means of oxygenated water and peroxide of calcium, in annulling the toxicity of a large number of toxins.

The same result may be obtained by means of ammonium persulphate. This is a powerful oxidising agent, which also possesses appreciable powers of disinfection. Unlike hydrogen peroxide and calcium peroxide, it may be employed in intravenous injections.

It has little toxicity ; a neutral salt, of a light base, it remains neutral while yielding its oxygen.

Oxygen acts not only upon the tetanus bacillus, but on its toxin ; hence its employment, not merely as a preventive, but also as a curative remedy. Wounds of a suspect nature, and wounds infected with the tetanic bacillus, should therefore be treated with oxygen.

Calcium Hypochloride.—According to certain writers, chlorine prevents the development of the tetanic bacilli and the production of toxins in the wound.

Despite these considerations, the various antiseptics have in reality hardly any effect upon the tetanic spores, whose powers of resistance, as we have seen, are considerable. On the other hand, they do act upon the ordinary microbes, the germs of suppuration, whose association with the tetanic bacillus is necessary to ensure its pathogenic action.

The employment of desiccated and powdered anti-tetanic serum has also been recommended in the case of extensive or lacerated wounds. But this procedure is far from sufficient alone as a protection against tetanus, unless it is seconded by the injection of the serum. In this connection Merieux found that a mixture of anti-tetanic serum and sub-gallate of bismuth, applied to a contaminated wound six hours after contamination, prevents the development of tetanus in the guinea-pig.

Physical Agents.—Hot or Cold Air.—Clinicians have conceived the idea of treating wounds suspected of tetanic infection by means of insufflations of air. The following treatment has been recommended : no sutures are made ; on the contrary, the wound is fully opened up ; lacerated, bruised, or mortified tissues are ablated as promptly as possible ; and the large wounds thus opened are treated by means of insufflations of hot air.

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This procedure, which dries the wounds and stimulates the production of fleshy vegetation, has been employed with success by various surgeons.

Cold air gives the same result, but its employment is slightly painful.

We may also employ an intensive current of air in the prophylaxis of tetanus. It will be readily understood that the increased supply of oxygen carried by a powerful current of air into all the recesses of a wound prevents the development of the anaerobic bacilli which cause tetanus.

These various procedures act principally upon the toxin, and it would be a matter of capital importance could we destroy this tetanic toxin by oxidation.

As a matter of fact, we already possess a means of destroying the tetanus bacillus itself, and thus of preventing the production of further toxin. The ultra-violet rays possess this bactericidal property.

Treatment by Light.—The action of the various rays of the solar spectrum, and of full sunlight, has long been utilised in the treatment of wounds in general. We know that under the influence of the ultra-violet rays wounds cleanse themselves and cover themselves with fleshy vegetation, while pain is alleviated.

The bactericidal action of light has therefore been employed in waging war upon the tetanus bacillus. Moreover, it has been proved experimentally that the toxin of tetanus is susceptible to the action of luminous rays, and that the spores are extraordinarily sensitive to the ultra-violet rays. Their employment should accordingly constitute one of the best methods of treatment.

In exposing a wound to light our principal motive is to excite an inflammation, an augmentation of the curative physiological processes.

This inflammation causes a hyperæmia and a serous exudation, of arterial origin, as well as an abundant proliferation of the tissues. The tetanus bacilli are therefore attacked in two ways : on the one hand, by a greater supply of oxygen in the tissues, caused by the inflammatory reaction provoked by the light ; and on the other hand, by the bactericidal action of certain rays of the spectrum.

It is certain, in view of the bactericidal action of sunlight, as well as its curative action upon wounds, that our wounded patients, especially those suspected of tetanus, ought to receive as much sunlight as possible.

Contagion.—From the prophylactic point of view, it must be remembered that wounds which upon cultivation yield pure cultures of tetanic bacilli are not always complicated by tetanus. Analogous facts are well known to obtain in the case of other infections—in particular, of diphtheria and cerebro-spinal meningitis ; and as in these infections, so in tetanus there are healthy carriers of the specific bacillus, who may become agents of contagion, if the surgeon neglects the strictest asepsis, and employs the same instruments in attending a number of patients.

There are no longer, in these days, “epidemics of tetanus,” but their memory proves the necessity of subjecting all instruments to a prolonged sterilisation, preferably by means of the autoclave, in order that the tetanic spores may not be carried from one wound to another.

It must be remembered, also, that some years ago several cases of tetanus were reported after the use of gelatine injections, and the employment of catgut (cases reported in France and America), and of felt in plaster-of-Paris splints. Great care must therefore be

taken to sterilise gelatine and catgut, as these may contain tetanic spores.

The Action of Cold.—Lastly, cold being one of the factors which favours the appearance of tetanus, care should be taken that the wounded man is not chilled during transportation, and that he is warmed directly he enters the ambulance or hospital.

Preventive Serotherapy

Despite the various preventive treatments already discussed, despite the most rigorous precautions of asepsis and antisepsis, it must be admitted that it is almost impossible to eliminate from a wound the tetanic germs which may infect it.

To protect the wounded man against the toxins secreted, he must be given one or several preventive injections of antitetanic serum.

Antitetanic Serum.—History.—The serum of animals immunised by the injection of progressively increasing doses of tetanic toxin possesses properties which have been utilised in the prevention and the attempted cure of tetanus. Behring and Kitasato, in 1890, demonstrated the antitoxic powers possessed by such a serum.

In 1892 Vaillard investigated certain points relating to the serotherapy of tetanus. The blood of the fowl does not neutralise the toxin, but it becomes antitoxic about three weeks after an injection of filtered culture into the peritoneum. This property persists for eight months. Vaillard also demonstrated that Nicolaïer's bacillus vegetates and elaborates toxin in the serum of protected animals; that it multiplies in the living tissues of an immunised animal; and that it is not attenuated by the prolonged action of the lymph of a

protected animal. In short, the serum is only *antitoxic*; it is not bactericidal.

In 1893 Roux and Vaillard went into the whole question of antitetanic serum. They demonstrated, giving technical details, that the serum is more active *in vitro* than when injected preventively. The guinea-pig, which is given 15,000 lethal doses of toxin, mingled *in vitro* with an equivalent quantity of serum, is able to resist the toxin. But this quantity of serum would have been insufficient to protect the guinea-pig against 15,000 lethal doses of the toxin. The immunity due to the injection of serum is acquired immediately, but it lasts only for a few days. The conclusions of Roux and Vaillard as to the preventive and curative properties of the serum are explicit. Injected simultaneously with the toxin, or within a few hours, it transforms a generalised and mortal tetanus into a local and curable tetanus; injected at the end of the period of incubation, or after the contractions have commenced, it is absolutely ineffectual. Since then the antitetanic serum has been employed only as a preventive. Nocard ardently recommends its employment; meanwhile sufferers from established tetanus are still given the serum, and certain cases of recovery are published, which are, however, of a highly debatable nature.

In 1898 Roux and Borrel recommended the treatment of established tetanus by the intra-cerebral injection of the serum. We shall refer to this method again when discussing the specific curative treatment of tetanus.

Preparation of the Serum.—Horses are immunised against the tetanic toxin by injecting, in the first place, doses of the toxin attenuated by the admixture of a solution of iodo-iodide. These injections are repeated every three or four days. About the twenty-fifth day,

the serum already exhibits a certain antitoxic power, which is then greatly reinforced by subcutaneous injections of pure toxin (10, 15, 20 c.c., etc., every two or three days). At the end of six weeks about 50, 100, 150, or even 350 c.c. are injected into the veins.

The horse supports these enormous doses of toxin—two drops of which would suffice to kill a non-immunised horse—without injurious effects.

Ten days after the last injection the serum is collected by venesection. To maintain the immunisation, large doses of toxin are again injected at intervals of a few days.

The antitetanic power of the serum survives for a very long time—a year, and even more; it is, however, preferable to employ none but recent serum.

The serum may be preserved in the dry state. When required for use it suffices to dissolve the dry serum in six volumes of sterilised saline water, but it is better to use the natural antitetanic serum.

To avoid the slight toxic symptoms which may accompany the injection of any serum, the serum may be warmed for twenty to thirty minutes to a temperature of 138° F. It is then less irritant.

Properties of Antitetanic Serum.—Antitoxic Powers.—If an appropriate mixture *in vitro* of antitetanic serum and a mortal dose of toxin be injected into an animal, no tetanic symptoms develop, and the animal survives the experiment. Roux and Vaillard were able to obtain a serum which, as we have already remarked, neutralises 100 mortal doses of toxin for a guinea-pig in doses of 1 in 100,000 c.c.

This antitoxic power being proved, the above writers established under what conditions, and in what

quantities, it could be utilised to prevent and even to cure tetanus.

Preventive Power.—1. *Against the Tetanus Toxin.*—An animal is given a subcutaneous dose of antitetanic serum ; then, forty to sixty minutes later, a mortal dose of tetanus toxin. As we have seen, it exhibits no tetanic symptoms, and survives.

We know, moreover, having dwelt upon the fact when considering the pathogenesis of atypical tetanus, that if the serum and the toxin are injected simultaneously at different points, the two substances are diffused through the tissues with unequal rapidity ; the toxin outstrips the serum, and the small quantity which then escapes the action of the antitoxin suffices to provoke those slight, limited forms of tetanus, which are nearly always curable.

Finally, if the serum is injected after the toxin, but before the onset of tetanic symptoms, the tetanus is always local. The later the injection of the serum, the larger must the dose be, in order to prevent the generalisation of the infection, and to avert a fatal result.

2. *Against the Tetanic Infection.*—Against experimental tetanic infection the preventive power of the serum has greater scope for action, since there is always a certain interval between the moment of inoculation and the moment when the toxin enters the circulation. On the other hand, the poisoning is continuous, the bacillus continuing to secrete its toxin as long as it continues to live.

The injection of the serum before infection or at the moment of infection indubitably and completely confers protection upon animals.

If the serum is injected intravenously after infection, protection is assured on condition that the serum is

injected within forty-eight hours of the tetanogenous inoculation, and is employed in sufficient quantity. If the serum is given by intramuscular injection its preventive action is doubtful, by reason of the slower absorption.

The immunity conferred by the serum is only temporary. After its elimination from the system, about the twelfth or fifteenth day, the tetanic spores immobilised by the phagocytes, being no longer affected by the serum, are able to develop, and to pour the toxin into the circulation at a time when there is no longer any antitoxin to arrest or to hinder its action.

The proof of these experimental data was established by Nocard, who experimented upon the horse and the larger domestic animals. Certain accidents from which these animals frequently suffer (wounds from nails in the road, or wounds inflicted by the farrier, etc.), and operations, such as castration, the amputation of the tail, and the reduction of hernia, are often enough followed by tetanus. Out of more than 2500 animals given a preventive injection immediately after operation, not one contracted tetanus. Out of 6000 others, treated one to four days after the infliction of wounds contaminated by dung, soil, earth, nails lying in the road, etc., only one contracted tetanus. At the same time there were 315 cases of tetanus among animals which received no preventive injection.

Combining the statistics collected by Nocard, Labat, and Vallée, among 16,917 animals which were given preventive injections, Vaillard discovered only one case of tetanus. No more conclusive statistics could exist.

We shall presently see that the preventive power of the serum when administered to human patients is indisputable, and that the cases of tetanus in wounded

men who have been treated with serum have occurred in instances where the serum was injected too long after the infliction of the wound by which the infection entered, and in which the bacillus continued to grow and secrete its toxin, as the injections were not repeated after the elimination of the serum.

Now that we have learned the fundamental properties of the antitetanic serum, and before indicating the principles of preventive serotherapy, we will briefly insist upon the innocuousness of the treatment, and its efficacy.

It would seem needless, after the numerous examples provided by the present war, to devote any space to this subject. We have been induced to do so, however, by the comparatively recent discussion of serotherapy and its dangers, and in particular by the report read by M. Netter before the Academy of Medicine, during its session of the 2nd of May last. This writer, however, declared that serious symptoms resulting from a first injection (the serum sickness which we shall presently describe), or from reinjections (anaphylactic accidents) are very rare ; above all, if the injection is made in the subcutaneous cellular tissue. Moreover, it must be admitted that the fear of accidents ought never to deter us from having recourse to serotherapy.

Certain physicians and surgeons who have denied the prophylactic value of the serum, and who have further accused it of being the cause of distressing symptoms, have shaken the confidence of many practitioners, and it is in order to refute the arguments invoked against the use of antitetanic serum that we feel obliged to emphasise the innocuousness and the efficacy of preventive serotherapy. It must unhappily be admitted that many of the deaths from tetanus recorded at the

beginning of the war were due precisely to the erroneous ideas which had been expressed concerning the dangers of preventive serotherapy.

Innocuousness of the Antitetanic Serum.—Some have attributed to antitetanic serum a series of symptoms which are common to the various therapeutic serums. These are not due to any peculiar property of the antitetanic serum ; and since the investigations of von Pirquet and Charles Richet these complications have been thoroughly understood. Discussing the accidents consequent upon serotherapy, we shall distinguish between those which follow a first injection and those which occur after reinjection. We shall describe, therefore, on the one hand, the serum sickness ; and on the other hand, the anaphylactic accidents.

Accidents following a First Injection.—Between the eighth and the fifteenth day after a subcutaneous injection of antitetanic serum, and occasionally later, but seldom sooner, the patient may exhibit three symptoms, associated or singly : an eruption, pains, and a slight rise of temperature.

The eruption, localised in the region of the face, presently becomes generalised, and may assume one of several different aspects. The urticarial, pruriginous forms are most frequent ; these consist of a diffused eruption of small or of moderate dimensions, or large red patches, which undergo progressive extension. Their aspect sometimes recalls the eruption of measles, or an erythema like that of scarlet fever. We have sometimes had patients sent to us as contagious cases, who were merely suffering from a serum eruption, as was demonstrated by the history and the development of the malady. In the course of the scarlatiniform serum erythema it should be remembered that desquamation

may occur in large patches, but in general it takes place earlier than in true scarlatina, and is not accompanied by angina.

Very frequently, too, the serum eruption is polymorphic ; it then consists of a morbillo-scarlatiniform erythema with predominance of urticarial elements.

The pains are felt in the joints, but no local swelling is observed. Usually they recall simple arthralgia without tumefaction, and more rarely simple neuralgia, or myalgia.

The elevation of temperature is slight ; the thermometer rarely rises above $100\cdot5^{\circ}$ F. Sometimes, however, as we shall see, it does exceed this figure.

This serum sickness, which is slight and without gravity, rarely continues for longer than four days. Its frequency varies greatly, according to the mode of preparing the serum ; it is less common in France (where it occurs in 13 to 14 per cent. of cases) than in Germany, which is due to the fact that the French serum is heated to 56° C. Even when the mode of preparation is identical, the syndrome develops more readily when the serum of certain horses is employed. It is not possible to explain precisely why this should be so.

The serum reaction is occasionally more marked. The temperature rises to 104° F., which, in the presence of a morbilliform erythema, and, above all, of a scarlatiniform erythema, does not facilitate diagnosis.

In such cases delirium may be observed, and agitation, or even meningeal reactions, with headache, stiffness of the nape, and Kernig's sign. The kidneys may in turn be affected, a condition which will be revealed, upon testing the urine, by the presence of albumin, and clinically, sometimes, by oedema.

In a few cases the lymphatic glands are hypertrophied. This veritable serum sickness does not usually last more than a few days, but it leaves behind it a prolonged adynamia. Regnier has even published an observation of a case in which, a week after the injection of the antitetanic serum, pericarditis supervened, the sequelæ of which persisted for a year.

A few fatal cases have been reported. Thus, Riche reported the case of a child, observed by Rilhac, which was rapidly fatal, with hypothermia and Cheyne-Stokes breathing. The subject had received a preventive injection of 10 c.c. of antitetanic serum.

Other writers have been so far mistaken as to inquire whether the preventive injection might not in certain cases have determined the appearance of the clinical signs of tetanus. In the majority of such cases there were meningeal reactions, with pseudo-tetanic contractures: temporo-maxillary arthralgia producing trismus, or arthralgia of the vertebral column determining a stiffness of the trunk. Lastly, if we very carefully analyse the majority of the fatal cases observed subsequently to serum injections, we find that in certain instances death was attributable not to the serum, but to acute septicæmia due to a septic injection. In certain cases, moreover, an alteration or accidental contamination of the serum may be incriminated.

The symptoms which follow a first injection of anti-tetanic serum are explained by the well-known toxicity which any animal serum presents for an animal of another species when injected into the latter. We know that a heterogeneous non-antitoxic serum of any kind causes similar symptoms.

Marfan, however, would attribute a certain action to

the antitoxin. According to him phenomena of precipitation occur *in vivo* analogous to those which occur *in vitro* when a toxin is brought into contact with the corresponding antitoxin. The precipitants formed in the blood after the injection of antitetanic serum into a wounded man already intoxicated by the tetanic toxin give rise to capillary embolisms which might be the anatomical substratum of the symptoms.

This theory is not enough to explain the symptoms which occur in the case of numbers of wounded men who are not already infected by tetanus.

Symptoms due to the Re[in]jection of Serum.—These may be early or late-appearing.

Symptoms appearing some time after Re[in]jection.—These may be summarised as eruptions, pains, and fever; they are of brief duration, and their prognosis is benign. They recall the symptoms which we have already mentioned as occurring after a first injection of serum, and differ from these only by a greater frequency and a shorter period of incubation. Thus, in France they are observed in 50 per cent. of cases, instead of 13 or 14 per cent., and they appear two to five days after reinjection, instead of eight to fifteen days after the first injection, as we have already seen.

Their pathogenesis is probably the same.

Symptoms which appear soon after Re[in]jection.—The immediate symptoms, on the other hand, are peculiar to reinjection, and present special characteristics. They may be local or general.

The *local phenomena* often follow a benign development.

At the point of reinjection, and almost immediately after the serum is administered, a more or less marked

redness makes its appearance, or a painful œdema, or urticaria. These abnormal phenomena are usually of brief duration, disappearing in a few hours, or at all events in a day or two.

Nevertheless, a local gangrene may be observed at the point of reinjection, accompanied by serious general indications. Eight such cases, followed by death, have been reported in the course of an incalculable number of reinjections of serum. However, all these cases occurred in the course of anti-diphtheritic serotherapy, and death appears to have been due to the coexistence of a dangerous state of infection.

General Symptoms.—The general immediate symptoms consist of a rapid collapse with diminution of arterial pressure. This collapse varies in duration. But in infected and debilitated subjects these disorders, which are but slightly marked at the outset, become aggravated instead of attenuated. Two cases of sudden death have been reported, one after a reinjection of anti-plague serum, and one after the administration of anti-diphtheritic serum. The history of these very exceptional accidents is elucidated by that of experimental reinjection (Richet and Portier, 1902).

We must conclude, from the experimental data, that the subcutaneous reinjection of serum is less dangerous than intravenous or intracerebral reinjection, which may cause death within a few minutes.

It must also be remembered that the symptomatology of experimental anaphylaxis does not make its appearance unless injection and reinjection are separated by an interval of a fortnight. It varies, moreover, in different animal species.

In man the frequency of anaphylactic accidents has been greatly exaggerated. We shall refer to two

definite cases, when discussing the curative treatment of tetanus.

In a generalised and complicated infection it is difficult to distinguish the symptoms which are dependent on the causal malady from those due to the reaction of the system under the influence of serotherapy or the therapeutic agents employed. Only the immediate or late-appearing symptoms which we mentioned as occurring in man recall the anaphylactic accidents of animals ; the local gangrene which may be observed at the point of reinjection is analogous to the gangrenous phenomenon of Arthur, and the cardiac collapse to the anaphylactic shock. However, serious symptoms are exceptional, and some of them may be avoided by taking a few precautions.

In this connection Marfan has recently laid stress upon the abuse of injections of heterogeneous serums ; the abuse of serums whose efficacy is doubtful, such as the anti-streptococcic serum, which certain physicians recommend in erysipelas ; the abuse of specific serums injected for a non-specific object—for example, the injection of anti-diphtheritic serum, or ordinary horse serum, in severe haemorrhage, diseases of the blood, ocular infections, etc. It must not be forgotten that the extension of serotherapy involves the risk, sometimes without the excuse of absolute necessity, of placing a large number of patients in a condition of hyper-sensibility in respect of serum reinjection which may be absolutely indispensable should they ever happen to be wounded, or to contract diphtheria, or cerebro-spinal meningitis, several months or years after the first injection of serum.

As it is the heterogeneous albumin which enters into action rather than the antitoxin, anaphylaxis occurs

indifferently when the injections, divided by a longer or shorter lapse of time, have been made with the same serums, or with serums differing in their antitoxins. Thus, a first injection of anti-diphtheritic serum or anti-meningococcic serum may become, on the occasion of an antitetanic reinjection, the origin of anaphylaxis.

Among the measures to be taken to avoid accidents, we must mention the preventive administration of chloride of calcium, in doses of 1 gramm per diem, and of adrenaline in doses of ten to fifteen drops of a 1 in 1000 solution. The adrenaline, whose hypertensive action is well known, will prevent or oppose the sudden fall of arterial pressure which is observed at the moment of the anaphylactic shock. These therapeutic agents, which are specially to be recommended on the occasion of reinjection in the curative serotherapy of tetanus, should be employed in preventive serotherapy when a few slight accidents have been observed at the time of the first injection, when the patient is infected and enfeebled, or when he exhibits a pathological taint. In a tuberculous patient, or one predisposed to urticaria, asthma, or hay fever, they should always be employed.

In all cases of wounded men who have previously, for any reason, received one or more injections of serum or serums, and in those cases especially in which anaphylactic accidents appear to be more readily produced, the anti-anaphylactic method of Besredka should be employed. This is based on the employment of small doses. If no marked anaphylactic symptoms are observed, it is possible, after a certain lapse of time, to inject large doses of serum without serious accidents. Thus, if in the first place we inject, subcutaneously, 0.5 c.c. to 1 c.c. of serum, we may, three or four hours later, inject the total necessary dose. This will be

given slowly, in order that the injection may be suspended upon the slightest threat of accidents.

Certain writers have recommended the addition to the serum of such substances as hydrochloric acid, iodine, sulphate of magnesium, formol, or chloroform, with the object of suppressing the effects of the anaphylotoxin. This method should be abandoned, for it has not given satisfactory results.

It follows, from these facts, that in practice these anti-anaphylactic precautions must be taken whenever it is possible to do so. It is obvious that in a dressing-station or field hospital, where there are great numbers of seriously wounded men, it is often impossible to discover whether the patient has previously received an injection of any kind of serum, or to wait three hours or longer between the injection of the small anti-anaphylactic dose and that of the massive dose which is required. In such cases there is no room for hesitation, it being a matter of urgency to inject all the wounded without distinction. Moreover, we are a hundred times more likely to expose the wounded man to the risk of tetanus by refraining from administering the preventive antitetanic injection than to produce serious anaphylactic symptoms by a serum reinjection which takes no account of his pathological past.

We have no hesitation in repeating that the fear of accidents following upon a serum reinjection, whether it has reference to tetanus, or cerebro-spinal meningitis, or diphtheria, has caused many more deaths than anaphylaxis itself.

The Efficacy of Preventive Serotherapy.—According to the opponents of the preventive serotherapeutic treatment, the serum is not only dangerous, but has no effect upon the final development of the disease. They base

their erroneous conceptions on the development of a few cases of tetanus, and their gravity, despite the employment of serotherapy.

Regnier, in this connection, reminds us that 41 cases of tetanus developed in spite of preventive injections, and that of 18 cases observed in France 13 were fatal. This figure, 41, taken from the statistics published by Vaillard in 1906, is by no means exaggerated, and Chattet, in 1909, increased it to 51. If we compare this figure with the numerous observations of cases which have developed in the absence of serotherapy, and if we subtract from it 19 cases which, according to a conscientious analysis undertaken by Chattet, should be regarded as doubtful or wrongly diagnosed, we see that such statistics are of little value as an argument against the genuinely efficacious character of preventive serotherapy, especially as we know that in some of the 32 cases on which we may rely the physician contented himself with powdering the wound with dried serum, a method which is recognised by all as blind and insufficient.

We have already referred to the eloquent statistics of the veterinary practitioners, and of Nocard in particular, concerning the importance of preventive serotherapy, and the results obtained by its employment. In human medicine also the majority of surgeons and physicians recognise that tetanus declares itself only when the preventive injection has been omitted. Moreover, the colonial wars have proved the value of preventive serotherapy, to say nothing of the recent statistics of Sieur and Bazy.

Sieur published in January, 1915, the statistics of tetanus in the army. He had observed 7 cases among 17,507 wounded, or .039 per cent., and this low

proportion was due to the systematic administration of preventive injections to all the wounded.

Bazy, among 10,986 wounded men in hospitals in the entrenched camp of Paris, reported only 129 cases, and in those sections of the army in which a preventive injection was given to every man wounded, the proportion of tetanic patients was .48 per cent., while in the other sections it was 1.299 per cent., or three times as high.

Out of 200 wounded men 100, without exception, and without selection, were given preventive injections ; only one contracted tetanus. In his case the prophylactic injection was given too late ; in reality the morbidity, for this series, was 0. A hundred soldiers subjected to the same conditions, but given no preventive injections, yielded 18 cases of tetanus, or nearly one case in five.

Fifty other wounded men, comprising 10 with wounds in a state of suppuration, produced by shell-splinters, and 40 with wounds produced by rifle-bullets, received each one a preventive injection ; not one of them had tetanus. This injection was given within five days of the infliction of the wound.

These figures appear to us the best demonstration of the efficacy of preventive serotherapy, and it would be still more efficacious if, as we shall now explain, physicians did not content themselves with a single injection, and if the requirements of serotherapy were more carefully fulfilled.

Rules of Preventive Serotherapy.—(a) As a general rule, every wound received in war should be regarded as contaminated by tetanic spores ; just as every wound, large or small, contaminated by the soil or produced by an infected object, calls for a preventive serotherapeutic injection.

While those wounds which are accompanied by extensive laceration or destruction of the tissues, together with complicated fractures, are most liable to be complicated by tetanus, we must not neglect seton-like wounds, or slight and superficial wounds, which are all the more likely to be the starting-point of tetanic infection because many surgeons regard them as unimportant and devoid of gravity.

We will even go so far as to say that in the case of every wound received in war time, whatever its situation, its extent, and the nature of the projectile causing it, the physician should have recourse to an injection of antitetanic serum as a prophylactic measure.

Similarly all accidental wounds, frost-bites or chilblains which have reached the ulcerative stage, or have mortified, and all burns, should be followed by preventive antitetanic serotherapy.

(b) The injection should be given *as soon as possible*, before the toxin has had time to diffuse itself through the system ; which it does, by the way, very rapidly. In many cases of tetanus which have developed in spite of a preventive injection, it is found that the injection was administered one, two, or three days after the traumatism.

(c) Contrary to the belief current among medical writers in the early days of serotherapy, *a single injection is not sufficient*. We know, in fact, that the period of immunity conferred does not exceed eight days, and that the tetanic bacillus may persist much longer than this. Among the sixty cases reported by Chattet in 1909, it is interesting to note that there were only four cases which developed after two injections (Desplas, Cazin and Leriche), and even in these cases the two injections were given at an interval of twenty-five days.

We have already considered the special development of certain forms of tetanus subsequent to preventive serotherapy, and need not further insist upon it here. Under these conditions tetanus may be local, and its onset insidious and precocious ; often, on the other hand, it is late in making its appearance. It follows that in the case of every doubtful wound there is reason to administer a second injection eight days after the first, and that in the case of contused wounds it is advisable to give three or four injections, at eight days' interval. This brief interval between the various injections has the additional advantage of protecting the patient against anaphylactic symptoms. We know, indeed, that these symptoms occur eight to ten days after the first injection, and that their onset assumes the form either of erythema or arthralgia, or respiratory disorders which pulmonary examination fails to justify. It is then that the three orders of symptoms appear which are characteristic of the anaphylactic state, and which, if they occur, should by themselves lead the physician to diagnose anaphylaxis. They are, to recapitulate :

1. Modifications of the pulse. These are variable ; acceleration of the pulse is a constant symptom, but sometimes it is not only rapid, but small and irregular, while sometimes it is unequal and intermittent.

2. Modifications of the respiration, which consist of an extraordinary amplitude of the respiratory movements. Sometimes the inspiration alone is prolonged and difficult, expiration taking place suddenly and noisily, and being followed by a very long pause. In certain cases stertor may be noted, or Cheyne-Stokes breathing.

3. Coma completes the clinical picture and con-

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stitutes, in association with the modification of the pulse and the temperature, the bulbar syndrome of anaphylaxis. Sometimes this coma makes a sudden appearance ; sometimes it is preceded by a period of somnolence, of apathy, of semi-coma. Its appearance, as a rule, follows that of the disorders of the pulse and the respiration. It announces the terminal period.

In addition to the bulbar syndrome, sphincter disorders and convulsions have been reported.

The development of these anaphylactic symptoms may end in death or recovery.

With regard to late-appearing tetanus, if we carefully analyse the observations published by Bérard and Lumière, it seems probable that in many cases inoculation was effected at the moment of the latest surgical intervention. Accordingly, even those patients who have received the two regulation injections shortly after being wounded should be given a fresh dose of anti-tetanic serum whenever it becomes necessary to resort to surgical intervention, as this may result in the liberation of the septic products latent in a suspect wound. Since Bérard and Lumière have applied this rule they have observed no further cases of late infection.

What is now the dose of serum which should be injected preventively ? In France the serum supplied by the Pasteur Institute is employed. Of this at least 10 c.c. should be injected as a dose. Certain physicians increase the amount for the first dose, injecting 15 c.c. or 20 c.c. the first time ; others recommend the injection of 10 c.c. daily for the first three days.

If the American serum be employed, the usual dose is again 10 c.c.

Lastly, the prophylactic serum should be administered subcutaneously.

An Adjuvant to the Prophylactic Serum.—Salol.—Certain writers recommend the employment, in addition to the antitoxin, of large doses of salol—4 to 6 grammes daily—as a preventive. Although the effect of this medication is doubtful, the drug may be utilised (being inoffensive), especially if there is a dearth of serum.

Curative Treatment

When the first signs of tetanus appear—trismus and contractures, generalised or localised—it is, of course, too late for prophylactic measures. We must endeavour to cure, or to struggle against, the declared tetanic infection. The treatment, then, must be specific ; we must resort either to antitetanic serum or to injections of carbolic acid. At the same time the treatment should be symptomatic, and the clinician must endeavour to find remedies for the accidents of tetanus : contractures, pains, and asphyxia.

Local Treatment.—Before discussing the various methods employed in the treatment of tetanus, it must be remembered that the tetanigenous wound must not be neglected, but must be treated. As in the prophylactic treatment of wounds, it must undergo disinfection, clearing out, and drainage. The usual antiseptics already mentioned will be employed. Insufflations of oxygen may also be employed, with the oxidising agents, oxygenated water, carbolic acid, and light ; they are not, as a rule, very effective. It must also be remembered that in some cases amputation results in a mitigation of serious symptoms.

The physician should always search for projectiles ; a great improvement has sometimes been observed after

the removal of foreign bodies (usually shell-splinters) on which the tetanic bacillus has been found.

Specific Treatment—Curative Antitetanic Serotherapy.—Certain writers question the curative value of the serum ; in any case it is less clear than its preventive action. From their experiments upon animals, Roux and Vaillard had already concluded that antitetanic serum possessed no curative action on declared tetanus. When, indeed, the first symptoms make their appearance, “ the toxin elaborated at the centre of infection has reached the nervous centres, and these may be so far invaded that death inevitably ensues. Certainly the antitoxin injected under the skin or into the peritoneum neutralises the toxin in circulation, but it does not remedy the lesions produced, and can do nothing against an accomplished poisoning ” (Vaillard).

The experiments of Nocard have also demonstrated that the serum has no modifying action upon confirmed tetanus. However, when injected into the brain itself (intra-cerebral injection) it may produce a successful result.

Thus Roux and Borrel conceived the idea of bringing the serum directly into contact with the nervous substance, and in guinea-pigs which had been rendered tetanic the intra-cerebral injection of the serum arrested the development of the tetanus, and the animals recovered. We shall presently consider the value of this method in human therapeutics.

Good results may also be obtained by injecting the serum in the neighbourhood of the nervous centres. Thus, parabulbar injections have produced 7 recoveries out of 13 cases in the dog (Camus).

However this may be, if we analyse the various statistics relating to curative serotherapy our judgment

is predominantly favourable ; the curative action of the serum cannot be denied. Thus, according to a first series of statistics, among 190 cases treated without serum the mortality was 79 per cent. ; among 330 cases treated with serum it was only 62·1 per cent.

In a second series of statistics 15 cases treated without serum (an admixture of slight cases and cases *in extremis*) yielded 3 recoveries and 12 deaths ; while 152 cases treated by antitoxin yielded 47 recoveries and 105 deaths.

If we combine the observations recently published by Comby, Massary, Roger, Réals and Thomy, and Étienne, with the table which the last writer published in 1900, we have a manifest proof of the efficacy of serotherapy in declared tetanus. We reproduce Étienne's table ; it is based on the period of incubation.

Incubation	Recoveries	Deaths	Mortality	Mortality before the Introduction of Serotherapy, according to Brunner
1 to 5 days .	3	7	70%	90%
5 to 10 " .	20	7	29%	70%
10 to 12 " .	7	1	13·3%	...
Over 12 " .	15	1	6·6%	...

Haushalter, employing the method of massive injections, has published statistics of 32 cases, in which he was able to determine the length of the incubation period. Although these statistics were obtained under bad conditions, since they refer to men wounded in battle, many of whom were left for several days on the battle-field, or to men taken to hospital while the tetanic paroxysms were at their height, this table (p. 194) is particularly instructive.

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In the military hospital at Nancy, L. Spillmann observed a mortality of 50 per cent. in the group of cases for which he was able to employ serum, or 9 deaths and 9 recoveries, 5 of these latter being cases of subacute tetanus and 4 of acute tetanus.

In curative serotherapy the surgeon should :

1. Commence the treatment as early as possible—directly the slightest symptoms make their appearance.

Incubation	Recoveries	Deaths	Mortality
5 days	1	1	
7 " . . . . .	...	2	
8 "	1	2	
9 "	1	...	
10 "	7	8	
11 "	2	1	
12 "	3	...	
13 "	1	...	
14 "	1	...	
16 "	2	...	
Or among 33 cases	19	14	42·5%

2. Employ massive doses of serum, without, however, exaggerating them ; we shall return to this point when discussing the various modes of treatment.

Modes of Treatment.—The antitetanic serum may be introduced into the system in several ways, which we shall proceed to describe : under the skin, into the muscles, into the veins, into the arteries, into the spinal cavity, and into the cranial cavity.

Subcutaneous Injections.—Surgeon-General (Médecin-Inspecteur) Chavasse has reported excellent results obtained by the employment of antitetanic serum in subcutaneous injections, the dose being 60 c.c. to 100 c.c., divided into two injections per diem, and repeated for two or three successive days.

According to the majority of clinical writers, 50, 80, or 100 c.c. of serum should be injected the first day, and then 40 to 50 c.c. daily, this being continued for at least eight days. It should be mentioned that this is the method least likely to give rise to seric accidents and anaphylaxis. We shall return to this point later on.

In any case, the intensive doses should be continued as long as the tetanic symptoms persist, but as the quantity of heterogeneous serum injected is not a negligible element, and as anaphylactic accidents occur principally after heavy doses, we think it possible to apply an efficacious serotherapeutic medication without employing such massive doses, for the injection of exaggerated doses may become a danger.

The treatment by subcutaneous injection is regarded by certain foreign writers (Germans) as of illusory value, and they employ it only as an accessory means. They inject the serum in the periphery of the wound, or they introduce the bulk of the serum into the system by intravenous or intralumbar injection, making injections in the region of the wound merely in order to augment the dose thus injected.

Intramuscular Injections.—Recommended by certain writers; this method does not appear to us to be advisable.

Intravenous Injections.—Recommended by José Penna in particular, many clinical writers regard these as constituting the best method of treatment. Intravenous injections should possess the advantage of being more active than subcutaneous injections. Still, it must be remembered that intravenous injections are more liable to provoke anaphylactic shock, and we consider, with Carnot, that their therapeutic superiority is by no means established. We know that in studying

the anaphylactic shock experimentally the liberating dose administered to animals prepared by a previous injection is administered by intravenous injection. The intravenous injection of a very small quantity of serum suffices to cause the immediate appearance of violent symptoms, which closely resemble those which Carnot recorded in his patient, the observation of whose case we have already reproduced in detail. The rapidity and violence of the anaphylactic shock, the hypotension, the cardiac derangement, and the cyanosis are such that we, like Carnot, never give intravenous injections of serum to patients who have already been inoculated, no matter what the date of the previous inoculation. Moreover, it results from the interesting experiments of Jean Camus that while curative anti-tetanic serotherapy produces visible effects during the course of declared tetanus, the results produced by intravenous injection are in no way superior to those obtained by subcutaneous injection.

Whatever may be the truth of this criticism, the partisans of this method recommend the introduction into the circulation of 100 c.c. of serum at the first injection, this dose being followed by one of 40 c.c.

Walter, Barnsby, and Mercier recommend injections decreasing from 50 c.c. to 10 c.c., associated with intravenous injections of chloral. These authors are said to have obtained 6 recoveries out of 8 cases.

Lemonnier reports a total mortality of 42 per cent., with 8 recoveries out of 19 cases of acute tetanus. Morax, Achard, Castaigne, and Touraine and Francon have obtained successful results. Torrès, in Buenos Aires, reports a mortality of 32 per cent. for 110 cases. He injected 120 c.c. in the first place, and afterwards 100 c.c.

Certain writers recommend that the injections should be warmed, as accidents are said to be avoided if this is done. According to the same writers, by the repetition of injections every two hours an immediate action of the serum may be noted. The general contracture of the muscles is said to be influenced but slightly, or not at all, but the cramps are said to lose visibly in frequency and intensity. Finally, the action of the serum is said to be more rapid than when administered by intralumbar injection.

In this connection, one writer even went so far as to treat a man suffering from a wound in the elbow, inflicted by a shell-splinter, and complicated by tetanus, by means of strong doses of serum, administered by subcutaneous and intravenous injection, which were continued until the appearance of anaphylactic symptoms. The wounded man recovered.

Despite these encouraging data, we think it as well to repeat that for the reasons already given we do not as a general rule recommend intravenous injection.

Intra-arterial Injections.—Heddaus has recommended intra-arterial injections, for the reason that the arterial circulation forms the most direct and efficacious path to the brain. The technical method employed is the following : the carotid artery is laid bare, under either general or local anaesthesia, and the needle is plunged into it obliquely in the direction of the blood-current. The serum is thus injected into the blood. In no case have there been disagreeable accidents. The small wound is closed with three or four Michel's clamps.

In France this method of carotid injections has been employed by Gauthier and Chattot. But as we have already remarked, the injection of the serum into the blood-stream does not yield better results in the treat-

ment and cure of tetanus, and we therefore reject it as dangerous and complicated.

Intra-cerebral Injection.—This method, which experimentally is infallible, according to the investigations of Roux and Borrel, has not, with human subjects, given the results which one might have expected from it.

Clinically speaking, failures are numerous, and indeed the rule ; moreover, a considerable number of serious and sometimes fatal accidents may occur (delirium, epileptiform convulsions, etc.). It is said that recent statistics have yielded 52 fatal cases out of 84.

Intra-cerebral injection is not at present practised.

Sub-arachnoid Injection.—This method, employed principally abroad, has been recommended in France by Doyen. This surgeon is said to make intra-rachidian injections of 60 c.c. the first day, and 40 c.c. the second day. He makes his patient lie in a bulbar declivity of forty-five degrees, claiming that the serum in this way reaches the nervous centres. He is said to have lost 3 patients out of 24 treated, thus obtaining a death-rate of 12 per cent.

In England Dr John Eyre, of London, and Dr Blair regard intra-rachidian injection as the best method of treating tetanus.

Clinically speaking, it must be remembered that lumbar punctures are very difficult in tetanus patients—even impossible, except under general anaesthesia, under chloroform by preference, in order to avoid bronchopulmonary complications. This intervention becomes a difficult complication in a contractured patient, for whom the most absolute repose is a fundamental necessity. Moreover, the injection may cause a slight inflammation of the serous membrane. Aseptic puriform meningeal reactions (Widal, Sicard and Salin)

are exceptional with French serum. However, when aseptic seric meningitis does result, the symptoms develop in the following order. Three or four hours after the injection, headache makes its appearance, together with a trace of Kernig's sign. The symptoms reach their maximum severity, according to Sicard and Salin, about the fifth or sixth hour, then becoming gradually attenuated and disappearing on the second day. Examination of the cerebro-spinal fluid shows :

1. The presence of polynuclear leucocytes, which are intact, and are not modified as at the commencement of an infectious meningitis.
2. The presence of red corpuscles in abundance.
3. At other times the liquid is found to have changed colour, being thick, opalescent, puriform.

This aseptic serum meningitis is never fatal.

Intra-nervous Injection.—Guided by Mayer and Ramson's experiments upon animals, certain physicians have tried intra-nervous injections, with a view to checking the invasion of the nerves by the toxin. Thus, the case has been reported of a laboratory attendant, who is said to have been saved by an injection of serum in the brachial plexus. These injections are said, moreover, to obviate the amputation of a limb. It is obvious that the introduction of the antitoxin into the nerves is effected more certainly if the brachial plexus is previously laid bare below the clavicle, the sciatic nerve in the bend of the thigh, or the crural nerve in the crease of the groin. In thin subjects this uncovering of the nerve is easy, and the serum may then be injected into it, but this method sometimes aggravates the local tetanus of a wounded extremity. In France two principal methods have been employed of acting upon the nervous trunks which conduct the toxin

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from the wound to the medullary and cerebral nervous centres.

These are : the *para-nervous injections* recommended by Sicard, which are made at the root of the limb, in the neighbourhood of the nerves ;

The *para-radicular injections* of Apert and Lhermitte, which are administered epidurally in the sacral region. They offer a double advantage : in the first place, they are less difficult to give than the preceding kind, and they surround all the nerve trunks proceeding from the lumbar and the sacral plexus with antitoxin, while the serum is not diluted as it is in the cerebro-spinal fluid. Vautrin, however, has been unable to discover that this method is of any greater efficacy.

Injections of serum *in immediate contact with the wound* have also been recommended. Thus, in four cases, Jousset conceived the idea of administering deep injections of 20 to 30 c.c. of serum about the pharynx, in the submaxillary region. These injections calmed the trismus and the dysphagia.

Of all these methods, one in particular is above all criticism—namely, *the subcutaneous method*. It is not sufficient by itself to cure tetanus, which demands, as we shall see, a combined treatment. And although no one method has proved itself to possess such efficacy as to impose itself above all the rest, we have deemed it of interest to recapitulate the various methods which have been successively employed in curative serotherapy.

Antitoxic Treatment

Treatment by Carbolic Acid (Bacelli's Treatment).—Bacelli, in 1888, advised the subcutaneous injection, in cases of tetanus, of carbolic acid in a 2 or 3 per cent.

solution. The injections should be given several times a day until the tetanus has terminated (twenty days and more), each injection containing .03 to .04 grammes of carbolic acid.

The happy results obtained by this treatment might point, according to some writers, to the fact that the cases treated were not severe. By this method at least 1 gramme, and even more, of carbolic acid must be introduced into the system. The injections are not very painful, and are not accompanied by any renal symptoms.

In the majority of cases, about half-an-hour after the first injection, a sedative effect is produced, with a diminution of the contractures. This phenomenon, manifested more particularly in cases of little gravity, is said to be more readily obtained with sulphate of magnesium. Consequently, certain writers consider that the carbolic acid treatment should be reserved for very slight cases.

To avoid any caustic action, certain physicians employ oily solutions (Margliano, Gerest, de Montille, Lesage).

In France this treatment is frequently employed, above all in combination with serotherapy (de Massary, Roullaud, Goumez, Laurent), or alone (Caillaud, Cornoglion, Migay), or in association with chloral (Sainton).

Sainton recommends the following procedure: Twice a day the patient is given an injection of 40 c.c. to 50 c.c. of a 2 per cent. solution of carbolic acid, so that the daily dose varies between 1.6 grammes and 2 grammes. The injection is subcutaneous, and is given, preferably, above the seat of the wound and in its neighbourhood. The injections may be continued for several days, and in the case of two patients Sainton

continued the treatment for nearly a month ; and he has, in two cases, introduced 48 grammes of carbolic acid into a patient's system without provoking symptoms of poisoning. The urine, in particular, never exhibited the characteristic black tinge. By this method, in association with chloral (12 to 16 grammes daily in two enemas), Sainton obtained positive results, although in two cases which terminated in recovery the symptoms had assumed a very grave development.

Intravenous and intra-spinal injections have not been much investigated.

Two writers have made experimental investigations with animal subjects, in order to determine whether carbolic acid has a prophylactic action. In mice previously injected with carbolic acid they succeeded in attenuating the tetanic infection, in retarding death, and even in averting it. Carbolic acid, then, should possess prophylactic and not merely curative properties.

Mode of Action of Carbolic Acid.—It is said to act on both the serum and the toxin.

In vitro, it is said to annul the toxic action of a large dose of a culture of tetanic bacilli.

In vivo experiment hardly bears out the hypothesis of action upon the toxin ; it does not modify experimental tetanus. At the same time, successful results have been obtained in human tetanus.

Thus, in the case whose particulars were published by Stewart and Laing in *The Lancet*, 26th December 1914, the tetanus became aggravated in spite of large doses of serum, chloral, and bromide ; it was cured in a month as a result of the subcutaneous injection of carbolic acid (2 c.c. of a 5 per cent. solution every two hours, under the skin of the abdomen).

Colloidal Metals.—As an antitoxic treatment, the colloidal metals might be employed: collargol, electrargol, lantol, colloidal gold.

Alcohol.—As chemical substances might exert a detrimental action on the antitoxin, alcohol has been suggested and recommended, as it should act as a narcotic.

Dutertre, in this connection, mentions a case of tetanus which he had occasion to observe some twelve years ago in the hospital at Boulogne-sur-Mer. The patient was a vagrant, who, subsequently to a wound in the face, inflicted by a kick, was attacked by tetanus. Some comrades who called to see him secretly brought him a litre of brandy, of which he drank every drop, so that by the evening he was dead drunk.

Next day the patient was better, and a few days later he left, cured. Dutertre compares the result obtained by alcohol in this case with the result obtained in cases of snake-bite. We know that many persons bitten by venomous snakes have made themselves drunk, and have escaped death.

As Dutertre remarks, the arterial tension, being increased by the absorption of a large quantity of alcohol, may perhaps retard the toxin production of the wound. Perhaps, also, the presence of a certain amount of alcohol in the blood annihilates the action of the tetanic toxin.

Salvarsan.—Favourable results have been reported from the employment of salvarsan in cases of tetanus. In the two first cases the employment of salvarsan was associated with the antitoxin treatment; the patients recovered. Of six other patients, two presenting a tetanus of medium severity recovered after the employment of salvarsan.

The four remaining cases of tetanus were of a serious character. Treated by salvarsan, one died of pneumonia; one recovered; the two remaining cases showed great improvement.

The writer who reports these results believes that salvarsan acts favourably upon tetanus. The grave and rapid development of tetanus is said to become milder and slower, and the duration longer. It is possible, says this writer, that salvarsan alone would act in the same way as antitetanic serum.

According to him, the treatment should commence with antitoxin directly tetanus is declared, and salvarsan should be given on the second and perhaps the third day. Two injections of .05 gramme of salvarsan should suffice.

Other writers have made investigations in order to judge of the value of this treatment, and it must be recognised that a number of cases have not been favourably affected by salvarsan.

The results at present being what they are, we do not advise the employment of this drug in tetanus, whatever the clinical appearance or severity of the disease.

Ascitic Fluid.—The injection of a serous exudate in cases of tetanus might, according to certain writers, lead to an amelioration of the dangerous symptoms. The liquid to be injected is collected in a sterilised flask and injected five to ten minutes later. This serous exudate is rich in lymphoid cells and albumin.

Other Antitoxic Agents.—Among the substances capable of neutralising the toxin *in vitro*, hydrochlorate of betain has been suggested (Jaboulay), and cholesterol, which is said to fix the toxin in the nervous system. Nervous opotherapy has also been recom-

mended, this suggestion being inspired by a mistaken interpretation of the experimental results obtained by Wassermann and Takaki in respect of the neutralisation of the toxin by cerebral pulp.

A. Lumière and Chevrotier have investigated the action of oxidising agents on the tetanic toxin, and their experiments, conducted first *in vitro*, then *in vivo*, with the guinea-pig, dog, goat, and ass, have led them to the conclusion that among the many substances tested the *alkaline persulphates* possess in the highest degree the property of exerting a destructive action on toxins.

Guinea-pigs which are given subcutaneous injections of a solution of *sodium persulphate* some minutes or some hours after the injection of the toxin always survive the experiment. The period of survival varies according to the dose of toxin administered.

Persulphate of sodium, according to Lumière and Chevrotier, exerts a constantly favourable action upon the paroxysms of contracture, alleviating or even suppressing them. The remarkable effect of the persulphates upon the tetanic spasm having been thoroughly verified in man, these writers have employed this method in all their cases of tetanus.

The treatment consists in injecting 20 c.c. of a 5 per cent. solution of pure neutral persulphate of sodium intravenously, once or twice a day, according to the gravity of the infection. These injections may be continued for eight to fifteen days, their frequency being regulated according to the development of the spasmodic symptoms ; they are given at longer intervals when the paroxysms cease, but more frequently if they persist.

The persulphate should be kept protected from

damp, and in the solid state, in sealed tubes containing quantities of 5 grammes. In solution it keeps only for a few days, and the solution is decomposed by heat. It should therefore be prepared as required, by dissolving each dose of 5 grammes in 100 c.c. of cold distilled and sterilised water.

When a solution is not employed within a week it should be thrown away.

The intravenous injection of this drug does not, as a rule, cause any reaction. However, nausea is sometimes observed two or three minutes after the injection, and it may be accompanied by vomiting, which is, however, unimportant.

Immediately after the administration of this medicament the paroxysms, as a rule, cease, or are at least greatly attenuated. The permanent contractures, and notably the trismus, persist without modification. According to Lumière the patients themselves beg for the injections, of which they quickly feel the results. They become, moreover, insensitive to external excitations, and no longer exhibit the afflicting paroxysms which make tetanus one of the most appalling and formidable of diseases.

Bottu's Mixture.—Routier recommends, in addition to the usual treatment with morphine and chloral, which fails in a great many cases, the employment of subcutaneous injections of a saline mixture furnished by M. Bottu.

This saline mixture is composed of pure and very stable persulphate of sodium, and phosphate of calcium sufficiently rich in free phosphoric acid to render the whole soluble in ten parts of water.

This preparation takes the form of a white crystalline powder, odourless, with an acid flavour, which keeps

perfectly without giving off oxygen, as do the commercial persulphates of sodium, which are always more or less decomposed, and, moreover, contain an often large proportion of sulphate of ammonium. The mixture contains one-fourth of its weight of phosphoric acid (H_3PO_4). This powder is completely soluble in distilled water, but should not be dissolved until the moment it is required when employed for subcutaneous injections.

In this way small reserves are injected into the system, which, by their slow decomposition, furnish oxygen and phosphoric acid almost continuously.

Subcutaneous injections of Bottu's mixture are given three times daily, the dose being 50 centigrammes of the salt dissolved in 6 c.c. of distilled water. According to Routier a careful watch should be kept on the patient, for in his opinion this treatment predisposes to pulmonary congestion.

These injections are rather painful, but they appear to arrest the pains and contractures. Thus, in the case of the soldier of the 8th Colonial Regiment, observed by Routier, of which we have already given the particulars, the cessation of the injections of Bottu's saline mixture, although the chloral was continued, was followed by the reappearance of the pains and contractures, which ceased when the injections were resumed.

To render these injections less painful, Routier recommends the addition of a third of a Pravaz' syringeful of morphia (1 per cent.) to the saline solution.

Symptomatic Treatment

Hygiene.—Whether the development of the disease is classical or atypical, the hygienic precautions which

such a malady calls for are so well understood that we need not dwell upon them here. We will merely remind the reader that as far as possible each tetanus patient must be isolated in an extremely quiet room, where all causes of excitation are eliminated.

Feeding by the mouth will naturally not be attempted except in those cases where the patient exhibits no contractures of the muscles of the throat, lest the so-called food pneumonia should supervene. Consequently, the majority of tetanus patients, as they suffer from dysphagic disorders, must be nourished by means of nutrient enemas, and in this connection enemas of an aqueous solution containing 7 to 10 per cent. of glucose have been recommended, or injections of serum, or intravenous injections of a 5 or 10 per cent. solution of sugar.

Diuretics are recommended, since it is recognised that the toxins are eliminated by the urine.

Warm Baths.—Tepid or warm baths constitute a means of calming, and according to some writers even of curing slight cases of tetanus, and those of medium severity. The beneficent action of baths, however, has long been noted. Two baths daily are given, the temperature being 97° F. to begin with, increasing to 106°–108° F. The duration of the bath should be twenty to thirty minutes, or at most an hour.

The majority of patients experience great relief from such baths. During the bath there is said to be relaxation of the trismus, an important phenomenon, since bathing would enable the patient to open his mouth more widely, in order to absorb food and medicine.

Care must always be taken of the wounds ; they should be protected from contact with the water by impermeable dressings.

Sedative Treatment.—*Chloroform.*—Martin and Darre and Walter have obtained good results by the employment of inhalations of chloroform in hyper-acute paroxysms.

Ether.—Intravenous injections of 5 to 15 c.c. of ether in 150 to 450 c.c. of normal saline solution (Noël and Souther) cause a profound sleep of several hours after each injection.

According to some writers, ether is said to destroy the combination of the toxin and the nerve-cells.

Potassium bromide, hyoscamus, belladonna, and curare, and, finally, compounds and derivatives of *opium*, may be employed as adjuvants to other sedative treatments.

Morphia, employed in subcutaneous injections of 1 centigramme four to five times per diem, produces repose, and causes the contractures to cease. To this may be added scopolamine, in doses of .5 milligramme per injection ; the action of morphine, associated with scopolamine, is, according to certain writers, more profound and more prolonged. However, morphia possesses the great defect of causing constipation, cerebral congestion, and respiratory paralysis ; and the patient seems more liable to develop bronchopneumonia.

Morphia, then, whether associated with scopolamine or not, must be administered prudently. Attempts are sometimes made to replace it by pantopon or paverin.

Chloral.—Chloral is certainly the drug most employed in the course of tetanic paroxysms ; it seems, moreover, to act better than morphine.

Chloral was recommended particularly by Verneuil as a symptomatic medicament in tetanus. By pro-

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curing repose and sleep, by causing a cessation of the contractions, it may maintain the strength and prolong life long enough to permit the disease to accomplish its development toward recovery.

There is almost always an immediate and very apparent amelioration ; the contractions diminish in intensity and even cease completely. But the symptoms which cease during sleep reappear upon waking, with much the same characteristics as before the administration of the drug (Mathieu). As for definite successes, they amount, according to Verneuil, to two-fifths of the cases treated ; this result is certainly exaggerated ; but it must be admitted that chloral increases the proportion of recoveries.

It is in chronic tetanus, or rather in the slowly developing form—that is to say, in the atypical forms which we have described—that successful results are most frequently obtained. We shall return to this point when, having described the various therapeutic methods in use, we discuss those which, in our opinion, should by preference be selected for the treatment of the abnormal forms of tetanus.

Chloral may be continued for fifteen or twenty days, and may, as Poncelet remarked, lead gently, through prolonged slumber, to convalescence.

Chloral is usually administered by the mouth or the rectum.

By the mouth, 1 grammie of chloral is given hourly until sleep and muscular resolution are obtained. This effect, once obtained, it is maintained without interruption, save to feed the patient. He may, in this way, be given as much as 6, 8, 10, 12, 16, or 20 grammes of chloral per diem, and this for several weeks, until the symptoms disappear.

We may, in fact, by commencing with weak doses, very soon contrive to exceed the fatal dose for an adult (this varying between 5 and 10 grammes), but it must be remembered that large doses may produce symptoms of chloralism, which we had perhaps better describe. Nicaise has observed toxic effects with doses of 5 grammes ; hence the necessity of avoiding massive doses of more than 3 or 4 grammes.

Chloral poisoning may be acute or chronic.

In the acute form, the phenomena of intoxication betray themselves in dramatic fashion, consisting of profound slumber, abolition of sensibility and the reflexes, and swelling of the face, which is sometimes livid, sometimes red. A more or less œdematosus swelling of the conjunctivæ may also be noted occasionally, sometimes with slight ecchymosis, epiphora, and diplopia. At the same time there is either a slow or a weak and rapid pulse, with retardation of the respiratory movements, a contracted, or more rarely a dilated pupil, and coldness of the extremities. The hypothermia may attain 95° or even 91.5° F., and erythematous eruptions may appear, in the form of large red patches, more or less numerous and extensive, urticarial or papular, or by exception purpuric.

Death sometimes occurs suddenly, and is due to the stoppage of the respiration, or more rarely to paralysis of the heart. It may even happen that the patient may succumb when he appears to have recovered.

Gubler divides the syndrome of chloralism into three periods :

1. A phase of excitation, usually but slightly marked, and of short duration.
2. A period of hypnosis.
3. A phase of narcosis or stupor.

Lastly, on awakening, a recurrent delirium may make its appearance (*Noir*) ; but the chronic form is that which is usually observed, although this occurs very rarely. It may be mentioned that it is betrayed by :

1. Digestive disorders.
2. Cutaneous eruptions.
3. Disorders of nutrition and respiration.
4. Nervous disorders.

The digestive disorders consist of vomiting.

The eruptions may assume various aspects.

The eruption commences with a diffused redness of the skin, presently followed by a sensation of respiratory oppression, with waves of heat. It may become generalised, but by preference affects the articulations on the side of extension, and the portions of the body chafed by the bed. The patches of eruption, varying in size and form, are usually slightly salient (Aviragnet).

The eruptions may assume any one of five aspects : the erythematous form, the papular form, the urticarial form (Gaucher), the vesical form, and the petechial form. These two last are the least usual.

In benign cases, which are most usual, the eruption disappears very quickly ; it gives rise to no febrile reaction or disagreeable subjective sensations. It disappears when the drug is discontinued, leaving no traces behind it ; but in those cases in which it is generalised the rash persists for several days, and is accompanied by fever and itching.

The eruptions are more frequent in summer, and are often determined by the ingestion of exciting beverages (coffee, tea, alcohol, etc.).

The disorders of nutrition are betrayed by oedema, ulcerations, petechiae, or purpura. The patient falls into a condition of considerable weakness, and exhibits

dyspnoea, with precordial anguish or an asphyxial condition.

The nervous disorders consist of insomnia, with agitation, or invincible sleep, weakening of the intelligence, enfeeblement of the senses, tremors, and occasionally epileptiform convulsions or paralysis. The patient usually succumbs while in a state of marasmus, or through enfeeblement and stoppage of the heart, or through paralysis.

In the event of gastric intolerance, or in the case of fully developed paroxysms, the chloral may be administered, as we have said, by the rectum. In this case the irritant qualities of the drug should be allayed by the addition of mucilage, or 120 grammes of milk and the yolk of an egg, making the enema up to 200 grammes. Usually 4 grammes of chloral are given in each enema, and this is repeated, if need be, three to four times a day.

Ore and Mayet have recommended the administration of chloral by intravenous injection, solutions of 1 in 20 or 1 in 30 being employed. This method has not been sufficiently tested to justify its preference over the buccal or rectal administration. However, Mayet reports a case in which, after two intravenous injections of 2 grammes and 1 gramme, separated by an interval of twenty-four hours, a comatose slumber supervened, with irregular pulse and breathing, death occurring three hours after the second injection (*Lyon Med.*, 1891).

To avoid these accidents it is best, according to Mayor, to employ an isotonic solution of a maximum strength of 2 per cent., while care should be taken to give the injection extremely slowly.

It must be remembered, also, that chloral is counter-indicated in heart disease, above all in cases of aortic lesions, *a fortiori* when there is degeneration due to

myocarditis (in alcoholics principally). Chloral is a cardiac poison, and weak doses must therefore always be employed in heart diseases or alcoholism. We have seen that massive doses should be avoided even in the case of adult patients free from any organic defect. If these conditions be scrupulously fulfilled chloral may, according to some writers, be sufficient alone. In certain rare and individual cases it may lead to recovery.

Sulphate of Magnesium¹

The effect of intra-cerebral injections of magnesium sulphate was studied about nineteen years ago by S. J. Meltzer. He found that after an intra-cerebral injection of a few drops of a 5 per cent. magnesium sulphate solution, the animal turned on one side and remained for hours in a stuporous condition. As a result of investigations extending over the last twelve years with Dr John Auer, Meltzer considers that the dominant action of magnesium salts on the living body, no matter by which way it is administered, consists in depression or inhibition of nervous activity. Consciousness is the first thing which is completely abolished. The unconsciousness is, as a rule, accompanied by a great muscular relaxation, while all the reflexes may still remain nearly unaffected. With a larger dose of magnesium the reflexes, too, begin to disappear, and with a still further increase of the

¹ A somewhat lengthy excursus on the physiological action of magnesium salts has been omitted, and a summary of the views of Meltzer, to whom we are almost entirely indebted for our knowledge of the action of magnesium, is inserted in its place. (*Vide "Inhibitory Properties of Magnesium Sulphate and their Therapeutic Application in Tetanus," S. J. Meltzer, Journal American Medical Association, vol. lxvi., No. 13, March 25, 1916, pp. 931-934.—Ed.*)

magnesium dose the motor nerve endings become paralysed—a curare-like action, which is accompanied, of course, by a simultaneous profound central action.

Chemically, calcium and magnesium are closely related substances. Biologically, however, they are strikingly antagonistic to one another. Auer and Meltzer found that an animal which may have been completely paralysed by a magnesium salt can be restored within a fraction of a minute by an intravenous injection of a calcium salt. It must be added, however, that this applies essentially to conditions in which the animal was exposed to the effect of magnesium for a comparatively short time. When the animal is saturated with magnesium for a longer period, the antagonistic action of calcium is less evident and is even not without some danger.

As is well known, the various neurons are not connected by direct continuity but by mere contact. That place of contact is termed by Sherrington "synaptic membrane." The contact between motor nerve and muscle is also not of a very solid character, and is termed by some also synaptic membrane. It is assumed that the magnesium solution contained in the lymph bathing the synaptic membrane enters with ease into these spaces and interrupts the passage of nervous, afferent impulses from one organ to the other, especially of such impulses for which there is a less readily prepared path for transmission than the paths existing for normal active reflexes.

What is said of magnesium applies also to calcium. When it is present in the lymph in a quantity larger than normal, it enters readily into the synaptic membrane and displaces or neutralises the obstructing or inhibiting magnesium.

The effect of magnesium salts was investigated extensively on animals and in a comparatively considerable degree also on human beings by intravenous, intraspinal, intramuscular, and subcutaneous injections. In all modes of administration the effect is, as stated before, unmistakably depressing in character. In intravenous application the effect is rapid, and when so used it must be guarded against possible harmful accidents. The inhibitory effect of an intraspinal injection sets in fairly early, and may last even longer than twenty-four hours. Intramuscular injections have a fairly rapid effect, but its duration is comparatively short. Subcutaneous injections act slowly but have a cumulative effect. Meltzer asserts that no other remedy is capable of relieving the furious symptoms of acute tetanus to such a satisfactory degree as do the injections of magnesium sulphate. On the basis of the above-mentioned theory he states that we may expect from the use of magnesium sulphate perhaps even more than a symptomatic action ; it is possible that the magnesium salts, accumulated in the lymph, enter into the synaptic membrane between two neurons, and thus prevent the wandering of the tetanus toxin through higher neurons and into the corresponding nerve-cells.

Influence of Magnesium upon the Temperature of the Body.—Experimentally, in the rabbit, a considerable lowering of the temperature has been noted as produced by sulphate of magnesium. This fall of temperature is not a direct consequence of the narcosis. It is a parallel phenomenon. The magnesium, doubtless, acts directly upon the centre regulating the production of heat. This fall of temperature, moreover, is noted after doses of magnesium which do not produce the slightest

symptoms of paralysis, still less of narcosis. A very careful examination of the thermal curve shows that a very marked parallelism exists between the temperature and the indications of magnesium poisoning. The fall of temperature is proportionate to the rapidity of onset of the symptoms of paralysis and narcosis. With a little practice one may, from the extent and the rapidity of the thermic fall, establish a prognosis of the gravity of the magnesium poisoning.

When narcosis sets in, and also, almost always, when the first symptoms of paralysis appear, these phenomena are immediately announced by a sudden and violent drop in the thermic curve. In the treatment of tetanus, therefore, we must employ sulphate of magnesium with prudence, and must systematically take the patient's temperature ; the indications with which it provides us are important guides in the matter of regulating the dose and avoiding accidents.

Action of Magnesium upon the Circulation.—It has long been known that the sulphate and other salts of magnesium are cardiac poisons. Experimentally, it has been proved that magnesium diminishes the blood-pressure without decreasing the frequency of the heart-beats ; and that the disorders of the circulation produced by magnesium cannot in any way be ameliorated by calcium. Thus, if we almost kill an animal with too large a dose of magnesium, the respiration disappears and the movements of the heart become less frequent, but an intravenous injection of calcium re-establishes the respiration, while the heart recovers only as the oxygenation of the system becomes improved.

Any therapeutic action of magnesium is accompanied by enfeeblement of the circulation. In the magnesium treatment, therefore, we must pay all the more attention

to the state of the respiration, inasmuch as calcium, used as an antidote, acts only on the respiration, and not at all on the enfeebled circulation.

Mode of Administration and Dose.—Experiments upon the rabbit have enabled us to discover the mechanism of the therapeutic action of magnesium.

Sulphate of magnesium injected under the skin is quickly eliminated.

Its action is in proportion to its degree of concentration.

Experiment has also proved that the rapidity with which magnesium injected under the skin is absorbed is very inconstant, above all when highly concentrated solutions have to be employed.

From these investigations it results that the subcutaneous injection, at one time, of large doses of sulphate of magnesium is, in the treatment of tetanus, an insufficient procedure. It might be advantageous in serious cases of traumatic tetanus, the duration of which is short. In less severe cases, with a chronic tendency, it constitutes only an indication of symptomatic treatment.

Intravenous Injections of Sulphate of Magnesium.—To obtain a rapid and lasting effect, intravenous injections should be employed.

It is possible, with a 3 per cent. solution of sulphate of magnesium in an isotonic solution, to obtain an action of the magnesium upon the terminals of the motor nerves which will last for some hours; an action which is in proportion to the rapidity of injection. By this means we may obtain a condition in which the magnesium, injected into the veins with a certain rapidity, is eliminated by the kidneys with the same rapidity. We may thus, with a given strength of

solution, and according to the rate of injection, affect all the peripheral nerves, while leaving the patient with sufficient powers of respiration, and without producing a notable diminution of the blood-pressure. The action of magnesium injected into the veins may be quickly arrested ; it is enough to remark that experimentally, in animal subjects, its action may be suddenly destroyed by injecting, into a vein, 2 c.c. of a 5 per cent. solution of chloride of calcium. The reaction produced by calcium is of short duration.

In the case of the human subject, therefore, we must pay great attention to the rate of injection, and none but chemically pure sulphate of magnesium must be employed. The commercial salt contains more or less water. (Chemically pure sulphate of magnesium crystallises with about seven molecules of water.)

Simultaneously with its paralysing action, sulphate of magnesium in solution has a very marked diuretic action. The respiration must be watched during injection, and the injection must be discontinued if the respiratory movements become too feeble, or if the patient exhibits cyanosis. In the event of danger an intravenous injection of a 5 per cent. solution of calcium chloride should be slowly administered. This injection will not prevent the action of subsequent doses of magnesium.

Intrarachidian Injection.—This method, recommended by Kocher, is not based on any specific action. In man this method is difficult, and it takes a very long time to inject a single dose. The injection causes a paralysis of the intrarachidian nerve-trunks. The action is more lasting, but the method possesses the drawbacks that we do not know the dosage of the injection, and the examination of the respiration during

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injection is difficult. Lastly, the action of calcium as an antidote has not been verified ; it seems hardly probable.

From experimental researches it follows that :

1. The subcutaneous or even intramuscular injection of a highly concentrated solution of sulphate of magnesium is the worst means of introducing the substance into the system, since we are not certain by such means of obtaining the greatest rapidity of absorption. The paralysing action will be of brief duration, consequently the injection will produce amelioration only in the slighter forms of tetanus.

2. The intravenous injection of sulphate of magnesium has, on the contrary, the advantage of exerting a lasting action on the nerves, and enables us to maintain this action for many hours. It might, therefore, be employed when the patient is in danger of death from asphyxia resulting from cramps. It gives the patient time to recover under the natural treatment of tetanus —that is, treatment by antitoxin. Death from cardiac disorders in tetanus patients results, as a matter of fact, from the intense muscular labour provoked by the cramps.

3. Treatment by intralumbar injections gives results which are longer in duration, and more in proportion to the dose, than those obtained by subcutaneous injection. In a serious case of tetanus intralumbar injection is very difficult, and it cannot readily be often repeated. Moreover, if accidents occur as the result of an overdose their treatment is problematical.

To refer no further to the data derived from experiment, which have thrown some light upon the treatment of tetanus by sulphate of magnesium, let us now consider the clinical results of this treatment.

Two writers have succeeded, by means of the mag-

nesium treatment, under conditions which endangered life, in rendering deglutition and respiration possible, in averting the danger of death during the painful paroxysms, in facilitating alimentation, and in diminishing the number of paroxysms. In one case the number of paroxysms occurring in a given time was thirty-three ; this was reduced to fourteen.

This treatment enables the patient to raise his head and open his mouth, while it dispels the dyspnœa. According to the same writers, sulphate of magnesium injected subcutaneously is an energetic remedy, diminishing the tetanic hyperexcitability and the violence and frequency of the painful paroxysms. It is especially useful in the spasms of deglutition and respiration which endanger the patient's life. It averts extreme weakness and asphyxia ; it diminishes the number and intensity of the cramps. It should not be employed in intrarachidian injections, the duration of which is limited, unless these are clinically necessary. As for technical details, a 20 to 25 per cent. solution should be employed for children and a 40 to 50 per cent. solution for adults. Additional supra-aponeurotic injections should be given, the injection being commenced with a little saline water.

Kocher advises the employment of a 10 to 15 per cent. solution. He injects 5 c.c. of this by intrarachidian, intravenous, or intramuscular injection, and according to this writer intrarachidian and intravenous injections are more dangerous than subcutaneous or intramuscular injections. The results have been encouraging. Kocher claims to have obtained, by this treatment, six recoveries in seven cases of tetanus. Other surgeons, in particular Powers, Miller, Fox, and Johnson, have reported cases of recovery.

Smithson, treating two cases of tetanus by this method, had one death due to paralysis of respiration. In some recent statistics (1914) a writer reports, as a result of bibliographical research, that twenty-seven cases of tetanus thus treated yielded only nine deaths.

How should sulphate of magnesium be employed, and in what doses?

Subcutaneous Injection.—By this method 10 to 15 c.c. of a 25 per cent. solution of sulphate of magnesium may be injected two to three times a day. This method is said in particular to have yielded excellent results in Monod's hands, as recorded in the observation of atypic tetanus already cited.

It should be remembered that very large doses may be given—as much as 100 c.c. even—and by employing a 40 per cent. solution as much as 60, 80, or 100 c.c. has been injected during the twenty-four hours in extremely serious cases.

Subcutaneous injection of sulphate of magnesium is really painful, and it is often necessary to give an injection of morphia before administering the magnesium.

The effect of the magnesium usually becomes visible after the lapse of half-an-hour, and lasts five or six hours. Under certain conditions the effect may last longer. After the injection the patient falls into a light sleep; the contractures and muscular cramps are greatly diminished. In slight cases and cases of medium severity these symptoms may even disappear completely.

Sulphate of magnesium injected under the skin has, then, a manifest sedative action, which establishes itself slowly and lasts for some time.

A great drawback is the great pain caused by sub-

cutaneous injection. This pain persists long after the injection, and an abscess may often be observed to develop at the point of injection, which, however, as a rule, quickly disperses after incision. This abscess is caused by a slight haemorrhage which invades the cellular tissue and the muscles around the point of injection.

Pain, and occasionally necrosis, are two complications which have caused the majority of physicians to abandon the employment of subcutaneous injections in the symptomatic treatment of tetanus by sulphate of magnesium.

However, the statistics are encouraging ; certain writers speak of 50 per cent. of recoveries ; others are less optimistic ; one foreign writer in particular is said to have obtained five recoveries and twelve deaths by this method.

Intrarachidian Injection.—By this method 2 c.c. of a 25 per cent. solution may be injected without accidents.

Griffon and Lian employ a solution of this strength, injecting 1 c.c. for every 25 lb. of the patient's weight.

Ramon and Dury inject 5 c.c. of a 25 per cent. solution. Kocher prefers 10 c.c. of a 10 per cent. solution. Other writers inject 6 to 8 c.c. of a similar solution. In most cases the sulphate of magnesium is observed to act effectually upon the contractures, but as Kocher has stated (who cured four patients out of five by this method), a sudden arrest of respiration may supervene. In one case this writer was even forced to resort to tracheotomy and artificial respiration.

Other writers, to obviate this danger, have advised the intravenous injection of chloride of calcium, or the lavage of the lumbar sac with a saline solution. It is also said that the respiratory disorders are amended by

withdrawing cerebro-spinal fluid and an injection of 1 milligramme of atropine.

It must also be remembered that intrarachidian injections of sulphate of magnesium may give rise to a sudden rise of temperature, cephalaea, erythema, zona, retention of urine, paralysis of the lower limbs, coma, and sometimes an intense meningeal reaction. All these inconveniences are perhaps due to impurities in the sulphate.

According to Bienfait and Leroy, who have published three observations, this method enables the physician to gain time, and the employment of an isotonic solution should obviate accidents.

The observations published by Sicard and Drevet and Debre clearly demonstrate the favourable influence of sulphate of magnesium on the painful paroxysms, and afford proof that sulphate of magnesium must be regarded purely as a symptomatic remedy, since death has supervened despite the cessation of the contractures.

Intravenous Injection.—In this method a 3 per cent. solution is usually employed. There are two difficulties to be avoided :

1. The solution should not be too dilute, or the circulation would be needlessly disturbed.
2. Neither must the solution be too concentrated, or it would cause osmotic disorders in the blood and tissues.

Intravenous injections of sulphate of magnesium have not been very largely employed in France. It does not seem that intravenous injection offers any advantages over intrarachidian or subcutaneous injection.

We mention it only for the sake of completeness in

this summary of the different treatments at present employed in combating the tetanic infection.

Symptomatic Surgical Treatment.—In the event of the grave asphyxial phenomena which result from the contractures of the respiratory muscles, certain writers have advised tracheotomy, and others phrenicotomy.

Tracheotomy.—One writer, in two cases of severe tetanus, with imminent danger of death as a result of cramps of the respiratory muscles, performed tracheotomy. The improvement in the respiration was surprising; the cyanosis disappeared almost entirely during all the paroxysms subsequent to the operation. It seems as though the occasional sudden death of tetanus patients in these cases is due, not to the cramps of the diaphragm and other muscles of the thorax, but rather to the trismus and the contracture of the muscles of the tongue, pharynx, and larynx.

Bilateral Phrenicotomy.—Jehn, of Zurich, has advised bilateral section of the phrenic nerves in the dangerous contractures of the respiratory muscles provoked by tetanus.

In these serious cases the diaphragm remains convulsively contracted in the position of maximum inspiration. The intercostal muscles and those of the neck and thorax are themselves contractured. They accordingly hold the thoracic cage immobilised in the position of forced inspiration. Active or reflex movements of the diaphragm and the ribs are consequently impossible, hence the impossibility of changing the volume of the pulmonary apparatus, the cessation of respiratory exchanges, and the imminence of asphyxia.

These mechanical reasons are a complete obstacle to artificial respiration. The thorax has lost all power of movement; the contractured diaphragm bounds it

below, while the osseous portion above the diaphragm becomes a sort of box, with rigid walls, imprisoning the lungs.

In these cases narcotics act too slowly. General anaesthesia cannot be attempted. Artificial respiration fails absolutely in these cases of tetanic cramps. As for sulphate of magnesium, the dose is too uncertain, and its action is transitory. Lastly, a simple or double pneumothorax, which has the advantage of liberating the lung, permits of the re-establishment of the intrapulmonary exchanges by artificial inspiration and expiration, but artificial respiration must be continued until the cessation of the paroxysm, and the grievous consequences of such respiration are well known.

Phrenicotomy completely paralyses the muscles of respiration, and the augmentation of the intrabronchial pressure, followed by a diminution of this pressure, gives rise to pulmonary movements.

Experimentally we know that the bilateral section of the phrenic nerve in an animal involves no disorders. Basing his argument on this fact, Jehn, in a case of tetanus with dangerous respiratory cramps, proposed bilateral phrenicotomy. Artificial respiration was found to be possible after the operation, and he was thus able to calm thirty-five grave attacks of asphyxia. But this paralysis of the diaphragm must not be resorted to except to permit of artificial respiration.

From Jehn's observation it results that the bilateral section of the phrenic nerves involves no danger, cardiac or other, and this paralysis of the diaphragm does not prevent expectoration. There is one fact which must be remembered—namely, that Jehn's patient was able to draw in only a small quantity of air

at each inspiration ; but clinical observation proves that the respiratory exchanges may be very greatly diminished without the production of marked organic disturbances. The organism, as a general thing, adapts itself to all such modifications.

Still, if we take into account the frequency of bronchopneumonia in cases of tetanus it seems that we should have recourse to phrenicotomy only in desperate cases with grave and acute asphyxia.

Conclusions

Mixed Treatment.—Now that we have described the various therapeutic methods successively recommended in tetanus, whatever its clinical development, we propose to conclude this chapter on the treatment of atypical tetanus by summarising the procedure which appears to us the best and wisest to follow when the clinician is confronted by an abnormal form of tetanus.

It is enough to recall the pathogenesis and development of the tetanic infection. In the infected wound the bacillus of Nicolaïer, favoured by saprogenous associations, secretes its toxin, which may, as the investigations of A. Marie have established, follow the course of the nerves until it reaches the medullary and bulbar centres, where it fixes itself, or may be transported by the circulation.

From this moment the infection is completed, and, as Sahli has clearly demonstrated, the nervous cells modified by the toxin react for a certain time on their own account—thus creating the tetanic syndrome. So true is this that the cellular reactions, with the contractures which are their symptoms, may continue to manifest themselves, may develop, and may determine

a fatal result when the toxins have been eliminated from the system.

In the development of tetanus, then, we may recognise three phases :

1. The bacillus secretes its toxins ; this is the phase of infection.

2. The toxins invade and fix themselves upon the nervous cells ; this is the period of intoxication.

3. The intoxicated nervous cells cause contracture ; this is the phase of cellular reaction.

As Étienne has justly remarked, there is every reason for believing that these different phases overlap in the clinical picture. It is possible that those nervous cells which are attacked by the toxin may be disintoxicated by antitetanic serum, at all events when their progressive impregnation has not given rise to irremediable lesions. They may become disintoxicated spontaneously, for contractures may yield where serotherapy has not been employed ; but the serum possibly exerts a disintoxicating action upon them. Such a disintoxication would occur in successive stages, and, as a rule, those cells which are first reached by the toxin—that is, those whose impregnation is elective—would be the last to become disintoxicated. Thus the trismus, which is the first clinical manifestation in the classic or cephalic forms of tetanus, is often the last tetanic symptom to yield to serotherapy.

On the whole, tetanus may be regarded as an infectious malady, as an intoxication, and finally a nervous malady ; the necessity of a mixed or combined treatment will accordingly be perceived.

A special treatment corresponds to each of the three phases of tetanic development : to the first phase corresponds the suppression of the infected centre ; to

the second, serotherapy ; to the third, the symptomatic treatment.

By combining these three treatments we neutralise the invading toxin, the object of the symptomatic anti-spasmodic treatment being to limit the reaction of the intoxicated cell upon excitation, while the local treatment of the wound aims at suppressing the spot where the toxins are produced.

It will be understood from this that an isolated treatment of incontestable value, such as serotherapy, is not in itself sufficient.

In dealing with a case of atypical tetanus we must therefore :

1. Disinfect the wound, where the toxins are produced. In this connection we refer the reader to the local treatment of tetanus, which we have already discussed.

2. Although localised, the atypical forms must not be neglected. Despite their benign development and occasionally prolonged incubation, they must, from the first symptoms, be treated as energetically and intensively as the normal forms. Finally, it must be remembered that these are the cases which are most susceptible of cure by massive doses of serum. But here we had best repeat that there is no excuse for exaggerating intensive doses, for they do not indefinitely increase the curative effect of the serum.

Moreover, the quantity of serum injected is by no means a negligible factor in the production of anaphylactic accidents, and if they may break out after small injections, they are far more liable to occur after heavy doses. Doses of 100 c.c. seem to us excessive, and by injecting a first dose of 50 c.c. and progressively diminishing it by 10 c.c. each day we doubtless obtain

equally good results. By this method, moreover, Barnsby and Mercier have obtained excellent results.

We ought also to mention, although we do not share his opinion, that Fricker recommends, in the atypical forms of tetanus, small injections of antitetanic serum (5 c.c.) repeated daily. According to this writer this is the treatment which best succeeds in these partial cases.

Subcutaneous injections alone must be employed, and even so the to-day well-known anti-anaphylactic precautions should be taken in order to avoid the appearance of serious accidents.

Heavy doses will never be administered straightway to patients who have received a preventive injection or injections. One should commence by injecting a small dose (·5 c.c. to 1 c.c.), and a few hours later the rest of the dose. The injection should be strictly subcutaneous and not intramuscular, the latter being more anaphylactic. In no case, however, must the fear of anaphylactic accidents prevent the employment of a treatment which may be efficacious ; all that is needful is to give none but subcutaneous injections and reasonable curative doses.

3. Lastly, with the serotherapeutic treatment we must associate a symptomatic treatment which is all the more to be recommended in the partial atypical forms of tetanus.

Chloral, in doses of 8 to 10 grammes ; carbolic acid, in doses of ·80 to 1 gramme ; subcutaneous injections of sulphate of magnesium (Monod)—these may exert a favourable and curative effect. It has even been claimed that symptomatic treatment has by itself led to recovery in certain partial forms of tetanus. It certainly seems that in these cases there was rather a

question of painful contractures in a wounded subject than of veritable localised tetanus. Bazy and Vaillard have justly remarked that in many cases bacteriological examination and experimental inoculation have failed to confirm the tetanic nature of the affection. One supposes, therefore, that a symptomatic therapeutics may have sufficed to work a cure in cases to which the name of tetanus has been wrongly applied.

Following these hints, despite the too sweeping assertion of Charles Laurent, the clinician may ensure for his patient the conditions most likely to lead to recovery. By the combination of the various therapeutic methods we believe that the mortality in cases of atypical tetanus can be still further reduced. However this may be, localised tetanus remains a serious complication of the wounds received in time of war, so that it is impossible to insist too strongly on the necessity of prophylactic treatment.

We can, without a doubt, diminish the number of cases of tetanus, whatever the variety :

1. By mechanically cleansing, and making anti-septic, all wounds contaminated by the soil or by suspect foreign bodies, immediately, or as soon as possible, after the infliction of the wound.

2. By injecting antitetanic serum preventively in all cases of septic wounds. A first injection should be given immediately after the traumatism, and a second eight days later. If tetanus is exceptional after a first injection, it is excessively rare after a second. We know, indeed, that after these preventive injections immunisation is not always perfect. Very exceptionally it is insufficient, permitting of an eventual outbreak of tetanus. But the residual immunisation has at least this advantage, in these very rare cases, of

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localising the infection ; and the malady being localised, it develops with a benign prognosis.

3. A fresh injection should also be given before any subsequent surgical intervention, and then the wounded man, in the vast majority of cases, will be safe from any tetanic complication.

SUMMARY OF THE FORMS OF TETANUS

CLASSICAL FORM

Incidence.—Since the introduction of preventive serotherapy, less frequent than formerly. Statistics relating to present war show that frequency may vary from 11·8 per 1000 (Bazy) to ·1 per 1000 (Vallette).

Symptomatology.—A usually brief prodromal period is observed in four-fifths of the cases, and is characterised by *neuralgic pains* in the vicinity of the wound, and dull or shooting or sometimes fulgurant pains along the course of the nerves in its neighbourhood, with spasms, stiffness, and slight and transitory contractures of the various muscles of the wounded area. The subject is next attacked by *trismus*. Then the neck muscles become stiff; dysphagia appears; the facial muscles are affected, causing *risus sardonicus*. The body is arched—*opisthotonus*.

The muscles of the abdomen become contracted, then those of the limb. The entire body now becomes completely rigid.

The contractures are usually intermittent, but recur on the slightest movement or stimulation. Occasionally contracture is localised to trismus without generalisation.

High fever—104° F. up to even 107·5° F.

Often there is retention of urine.

Lastly, the respiratory muscles are affected and the patient succumbs to asphyxia.

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Sometimes emprosthotonus, pleurothotonos, or orthotonus replace the opisthotonus.

Diagnosis.—Easy when symptoms are complete.
(1) If trismus is the only sign at outset eliminate. Mental affections and angina.

(2) Acute strychnine poisoning gives rise to similar symptoms.

Prognosis.—Grave. Mortality despite serotherapy is still high. Recent statistics show a death-rate amounting to 64 per cent.

ABNORMAL FORMS

A. SPHLEANCNIC TETANUS

Incidence.—Very rare. It occurs in man quite exceptionally after abdominal operations or uterine wounds.

Symptomatology.—Long incubation. Short duration of the malady.

Non-generalisation of the contractures which involve the muscles of deglutition and respiration.

Dyspnœa is marked and always alarming.

Diagnosis.—Eliminate hydrophobia.

Prognosis.—Always fatal.

B. CEPHALIC TETANUS

(1) Non-paralytic Type

Incidence.—Very rare. No signs of facial paralysis. Always wound of head.

Symptomatology. (a) Simple cephalic tetanus. Trismus only with contraction of certain face muscles.

(b) Dysphagic form. Pharyngeal spasms rendering

alimentation difficult. Sometimes respiratory muscles affected.

(c) Hydrophobic form. Violent convulsive spasms, starting in wound, radiating to muscles of neck, face, and pharynx, finally reaching the diaphragm, to cause grave respiratory disturbance.

Diagnosis.—Eliminate true hydrophobia in types (b) and (c).

Prognosis.—Type (a) grave. Still more gloomy if respiratory disorders appear.

In the dysphagic and hydrophobic forms nearly always fatal.

(2) *Paralytic Type*

Incidence.—Rare. Follows a wound of head in the region innervated by the trigeminal.

Symptomatology.—Facial paralysis with contractures localised principally in the cephalic region, above all in the facial region, but the tetanus may slowly invade other regions.

Facial paralysis may precede, follow, or accompany the contractures. It is usually unilateral, occurring on the same side as the wound. If the wound is median, there may be facial diplegia. The paralysis may be partial or complete.

Complete facial paralysis affects the whole seventh nerve, and may cause hyperacusis and disorders of taste.

Partial facial paralysis may involve either the upper or lower branches of the facial nerve.

Diagnosis.—Eliminate (1) direct traumatism involving the facial nerve; (2) hysteria; (3) tic douloureux; (4) traumatic reflex spasms.

Prognosis.—Less gloomy than in usual forms of

tetanus. Mortality in France does not exceed 50 per cent. The facial paralysis usually disappears without leaving permanent traces when the patient recovers from the tetanus.

(3) *With Paralysis of the Motor Nerves of the Eye*

Incidence.—Comparatively rare. Occurs when tetanus follows trauma of the eye and adjacent parts.

Symptomatology.—Occasionally ocular paralysis is earliest manifestation.

The third nerve is always involved; the fourth and sixth may be paralysed also.

Ptosis, strabismus, and a more or less complete paralysis of the external muscles of the eye are the ordinary symptoms.

The internal muscles of the eye may be affected also.

This form may coexist with facial paralysis.

Diagnosis.—Eliminate (1) ocular spasms; (2) cerebro-spinal meningitis; (3) tubercular meningitis; (4) fracture of the orbit; (5) fracture of the base of the skull.

Prognosis.—Cases of ophthalmoplegic tetanus have been fatal. Chronicity is in favour of recovery. The prognosis of the ocular paralysis *per se* is good. In only one case did the ophthalmoplegia last three months.

(4) *With Paralysis of the Hypoglossal (Rare)*

Symptomatology.—Syndrome of labio-glosso-laryngeal paralysis.

C. UNILATERAL TETANUS

Incidence.—Existence debated. In any case, exceedingly rare.

Symptomatology.—In general the symptoms are for some time confined to one side of the body, and are still predominant there during generalisation, giving rise to pleurothotonos.

Diagnosis.—Eliminate irritative cortical lesion.

Prognosis.—That of classical form of tetanus.

D. TETANUS OF THE LIMBS

(1) *Monoplegic Form*

Incidence.—Rare. But observations more frequent since first case published by Courtellement.

Symptomatology.—The first symptoms consist of a slight stiffness either of the muscles of the wounded limb or the masseters. The onset may be early or late. The first signs are usually pain in the wounded limb, soon followed by a localised contracture. Clonic movements occurring in paroxysms may first appear, followed by tonic contracture, or the contracture may be the first symptom, the limb feeling, on palpation, like a mass of wood.

Sometimes there is slight transitory trismus. There is little or no stiffness of the neck.

There is often a more or less marked contracture of the abdominal muscles.

There is little fever. Temperature is about $100\cdot5^{\circ}$ to $101\cdot5^{\circ}$ F.

The pulse is moderately rapid—100 to 120 per minute. Not irregular.

The facial expression is anxious.

There is constant exaggeration of the deep reflexes, often with ankle and patellar clonus and hyper-excitability of muscles and nerves under electrical stimulation.

Diagnosis.—Eliminate (1) spasmodic monoplegia due to cerebral or medullary lesion ; (2) irritation of motor and mixed nerves ; (3) contractures due to lesions of bones and joints ; (4) tetany ; (5) hysterical contracture.

Prognosis.—If development be chronic, there is a tendency toward recovery. The prognosis is, however, grave, on account of possible complications or secondary generalisation.

Routier observed six cases with three deaths. Nevertheless, it often tends toward recovery, except in cases of late post-operative tetanus.

(2) *Paraplegic Form*

Incidence.—Rare.

Symptomatology.—According to the seat of the contractures one may distinguish :

(a) Superior paraplegic form. Upper arm, forearm and hands forcibly flexed.

(b) Inferior paraplegic form. Limbs in forced extension. Foot in position of talipes equinus. Lower leg extended from the thigh, the patella strongly immobilised. The thigh extended at the pelvis. The whole limb hard, as if petrified.

Diagnosis.—Eliminate tetany, hysterical paraplegia, lesion of cord.

Prognosis.—Favourable. Recovery the rule.

E. LOCALISED TETANUS—ABDOMINAL THORACIC TYPE (One Case)

Symptomatology.—Tetanus confined to the abdomino-thoracic muscles. Not affecting other groups of muscles except masseters, which are slightly affected.

F. ATTENUATED TETANUS DEVELOPING SLOWLY
AFTER A PROLONGED INCUBATION (Very Rare)

Symptomatology.—The first symptoms consist of a slight stiffness, either of the muscles of the wounded limb or the masseters. The facial expression is abnormal.

The general condition remains excellent, and the patient is able to walk. Muscular hypertonia without paroxysmal contractions.

Temperature normal.

Exaggeration of the deep reflexes and excessive excitability of the muscles and nerves to electrical stimulation.

Diagnosis.—Eliminate hysterical conditions.

Prognosis.—Good.

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By L. IMBERT, National Correspondent of the Société de Chirurgie, and PIERRE RÉAL, Dentist to the Hospitals of Paris. With a Preface by Medical Inspector-General FÉVRIER. Edited by J. F. COLYER, F.R.C.S., L.R.C.P., L.D.S. With 97 illustrations in the text and 5 full-page plates. Price, 6s. net. Postage 5d. extra.

Previous to the present war no stomatologist or surgeon possessed any very extensive experience of this subject. Claude Martin, of Lyons, who perhaps gave more attention to it than anyone else, aimed particularly at the restoration of the occlusion of the teeth, even at the risk of obtaining only fibrous union of the jaw. The authors of the present volume take the contrary view, maintaining that consolidation of the fracture is above all the result to be attained. The authors give a clear account of the various displacements met with in gunshot injuries of the jaw and of the methods of treatment adopted, the latter being very fully illustrated.

In this volume the reader will find a hundred original illustrations, which will enable him to follow, at a glance, the various techniques employed.

FRACTURES OF THE ORBIT AND INJURIES OF THE EYE IN WAR

By FELIX LAGRANGE, Professor in the Faculty of Medicine, Bordeaux. Translated by HERBERT CHILD, Captain R.A.M.C. Edited by J. HERBERT PARSONS, D.Sc., F.R.C.S., Temp. Captain R.A.M.C. With 77 illustrations in the text and 6 full-page plates. Price, 6s. net. Postage 5d. extra.

Grounding his remarks on a considerable number of observations, Professor Lagrange arrives at certain conclusions which at many points contradict or complete what we have hitherto believed concerning the fractures of the orbit: for instance, that traumatisms of the skull caused by fire-arms produce, on the vault of the orbit, neither fractures by irradiation nor independent fractures; that serious lesions of the eye may often occur when the projectile has passed at some distance from it. There are, moreover, between the seat of these lesions (due to concussion or contact) on the one hand, and the course of the projectile on the other hand, constant relations which are veritable clinical *laws*, the exposition of which is a highly original feature in this volume.

The book is thus far more than a mere "document," or a collection of notes, though it may appear both; it is, on the contrary, an essay in synthesis, a compendium in the true sense of the word.

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The number of soldiers affected by hysterical disorders is great, and many of them have been immobilized for months in hospital, in the absence of a correct diagnosis and the application of a treatment appropriate to their case. A precise, thoroughly documented work on hysteria, based on the numerous cases observed during two years of war, was therefore a necessity under present conditions. Moreover, it was desirable, after the discussions and the polemics of which this question has been the subject, to inquire whether we ought to return to the old conception, or whether, on the other hand, we might not finally adopt the modern conception which refers hysteria to pithiatism.

This book, then, brings to a focus questions which have been especially debated ; it does not appeal exclusively to the neurologist, but to all those who, confronted by paralysis or post-traumatic contractures, convulsive attacks, or deafness provoked by the bursting of shells, have to grapple with the difficulties of diagnosis and ask themselves what treatment should be instituted. In it will be found all the indications which are necessary to the military physician, summarized as concisely as is possible in a few pages and a few illustrations.

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Of all the medical works which have appeared during the war, this is certainly one of the most original, both in form and in matter. It is, at all events, one of the most individual.

The authors have preferred to give only the results of their own experience, and if their conclusions are not always in conformity with those generally accepted, this, as Professor Pierre Marie states in his Preface, is because important advances have been made during the last two years; and of this the publication of this volume is the best evidence.

Thanks to the method of radiographing the convolutions after filling the furrows, which has become sufficiently exact to be of real service to the clinician, the authors have been able to work out a complete and novel cerebral pathology, which presented itself in lamentable abundance in the course of their duties, which enabled them to examine and give continued attention to many thousands of cases of head injuries.

Physicians and surgeons will read these pages with profit. They are pages whose substance is quickly grasped, which are devoid of any display of erudition, and which are accompanied by numerous original illustrations.

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This volume, therefore, considers the penetrating wounds of the abdomen encountered in our armies under the triple aspect of *doctrine, organisation, and technique*.

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Hospital practice had long familiarised us with the vascular wounds of civil practice, and the experiments of the Val-de-Grâce School of Medicine had shewn us what the wounds of the blood-vessels caused by modern projectiles would be in the next war. But in 1914 these data lacked the ratification of extensive practice. Two years have elapsed, and we have henceforth solid foundations on which to establish our treatment. This manual gathers up the lessons of these two years, and erects them into a doctrine.

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Required, during the last two years, to examine and equip with appliances hundreds of mutilated soldiers, the authors have been inspired by this guiding idea, that the functional utilisation of an appliance should take precedence of considerations of external form. To endeavour, for æsthetic reasons, to give all subjects the same leg or the same arm is to risk disappointment. The mutilated soldier may have a “show hand” and an every-day hand-implement.

The manufacturer will derive no less profit than the surgeon or the mutilated soldier himself from acquaintance with this compendium, which is a substantial and abundantly illustrated volume. He will find in it a survey and a reasoned criticism of mechanisms which notably display the ingenuity of the makers—from the wooden “peg” of the poor man, together with his “best” leg and foot, to the artificial limb provided with the very latest improvements.

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This volume is divided into two parts, the first dealing with the clinical features and the second with the epidemiology and prophylaxis of typhoid fever and paratyphoid fevers A & B. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum therapy and vaccine therapy, and general management of the patient.

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This, the second of the volumes which Professor Vincent and Dr. Muratet have written for this Series, was planned, like the first, in the laboratory of Val-de-Grâce, and has profited both by the personal experience of the authors and by a mass of recorded data which the latter years of warfare have very greatly enriched. It will be all the more welcome as hitherto there has existed no comprehensive handbook treating these great epidemic diseases from a didactic point of view. The articles scattered through the reviews, or memoirs buried in the large treatises, did not respond to the need which was felt by the military physician, in France as well as in distant expeditions, of a work which should bring to a common focus a number of questions which were, in general, very imperfectly understood.

The authors review, in succession, the Clinical details, the Epidemiology, and Prophylaxis of *Dysenteries, Cholera, and Typhus*. In the section dealing with *Prophylaxis*, in particular, will be found practical advice as to the special hygiene possible in the case of large collections of people placed in conditions favourable to the development of these diseases.

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Of all the infections which threaten our wounded men, tetanus is that which, thanks to serotherapy, we are best able to prevent. But serotherapy, when it is late and insufficient, may, on the other hand, tend to create a special type of attenuated and localised tetanus ; in this form the contractions are as a general rule confined to a single limb. This type, however, does not always remain strictly monoplegic ; and if examples of such cases are rare this is doubtless because physicians are not as yet very well aware of their existence.

We owe to MM. Courtois-Suffit and R. Giroux one of the first and most important observations of this new type ; so that no one was better qualified to define its characteristics. This they have done in a remarkable manner, supporting their remarks by all the documents hitherto published, first expounding the characteristics which individualise the other atypical and partial types of tetanus, which have long been recognized.

The preventive action of anti-tetanic serum should not cause us to disregard its curative action, the value of which is incontestable. However, a specific remedy, even when a powerful specific, cannot act upon all the complex elements which constitute a disease ; and tetanus presents itself, in the first place, as an affection of the nervous system. To contend with it, therefore, a symptomatic medication should come to the aid of a pathogenic medication.—*Professor Widal.*

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It seemed, with reason, to the editors of this series that room should be found in it for a work dealing with syphilis considered with reference to the army and the present war.

The frequency of this infection in the army, among the workers in munition factories, and in the midst of the civil population where this is in contact with soldiers and mobilized workers, makes it, at the present time, a true epidemic disease, and one of the most widespread of epidemic diseases.

Dr. Thibierge, whose previous labours guarantee his peculiar competence in these difficult and important questions, has, in writing this manual, very notably assisted in this work.

But the treatment of syphilis has, during the last six years, undergone considerable modifications ; the new methods are not yet very familiar to all physicians ; and certain details may no longer be present to their minds. It was therefore opportune to survey the different methods of treatment, to specify their indications, and their occasionally difficult technique, which is always important if complications are to be avoided. It was necessary before all to state precisely and to retrace, for all those who have been unable to follow the recent progress of the therapeutics of venereal diseases, the characters and the diagnostic elements of the manifestations of syphilis.

Of late years, moreover, new methods of examination have entered into syphilitic practice, and these were such as to merit exposition while the old elements of diagnosis were recalled to the memory.

In short, this little volume contains those essentials which will enable the physician to accomplish the *entire* medical portion of his anti-syphilitic labours ; it will also provide him with the elements of all the medical and extra-medical advice which he may have to give the civil and military authorities in order to arrive at an effective prophylaxis of this disease.

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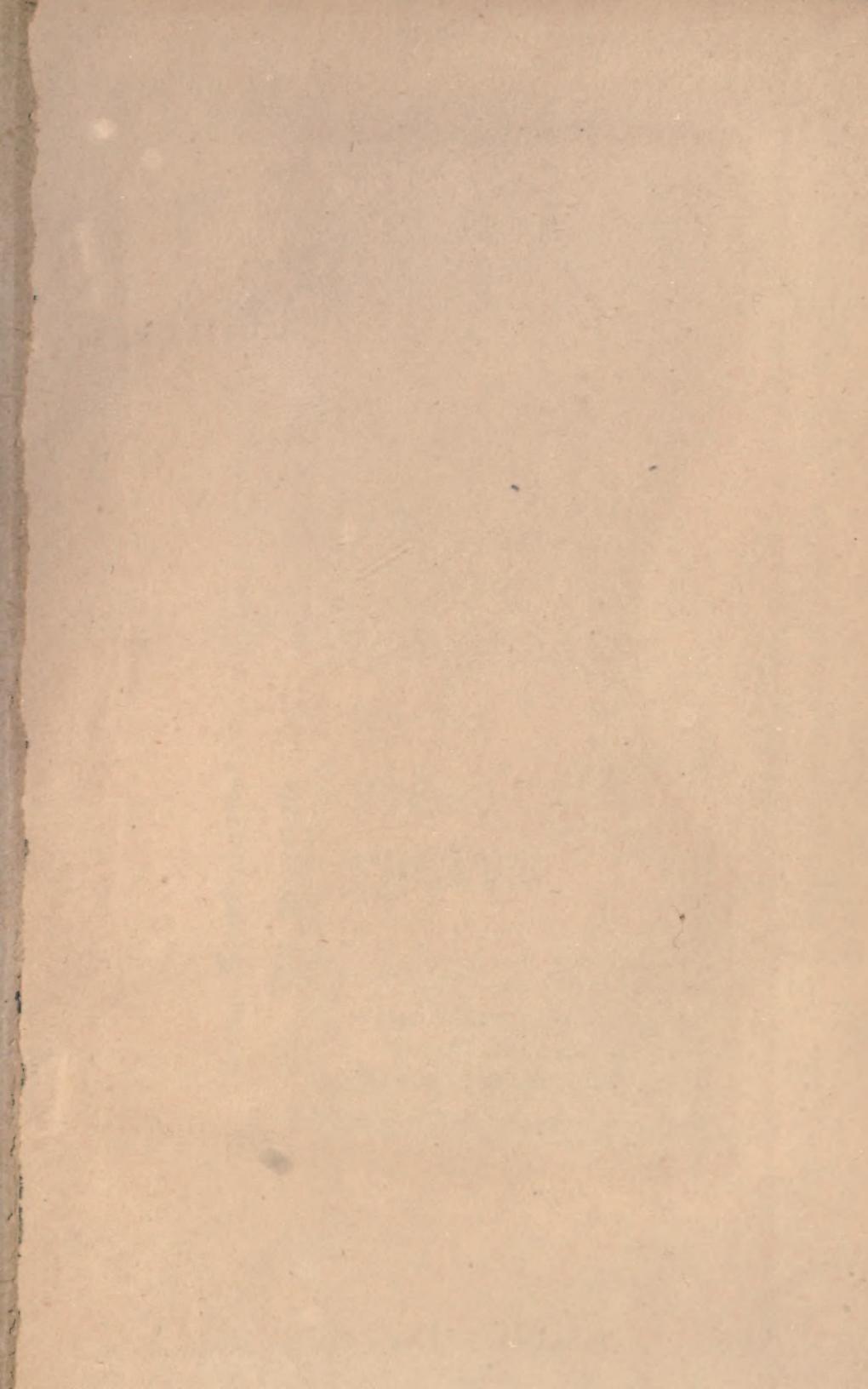
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